

Daily report

16-05-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

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PJC and MC received funding from "la Caixa" Foundation (ID 100010434), under agreement LCF/PR/GN17/50300003; CP, DL, SA, MC, received funding from Ministerio de Ciencia, Innovación y Universidades and FEDER, with the project PGC2018-095456-B-I00;

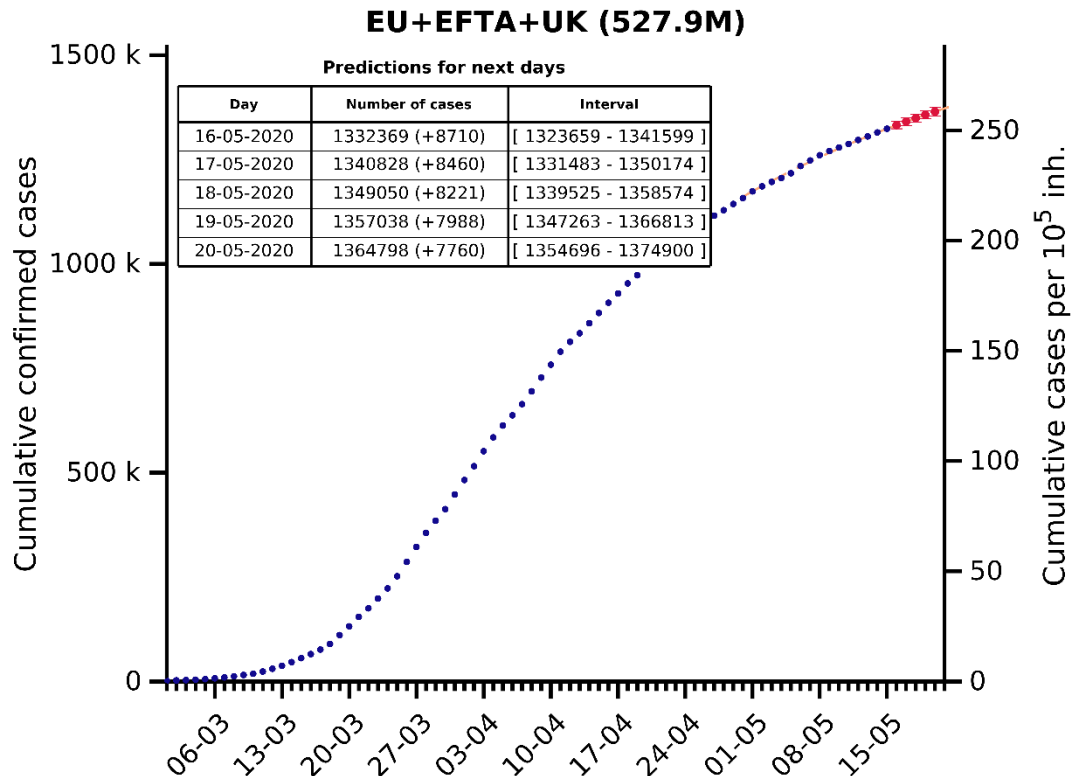
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(0) Executive summary – Dashboard

Weekend short version

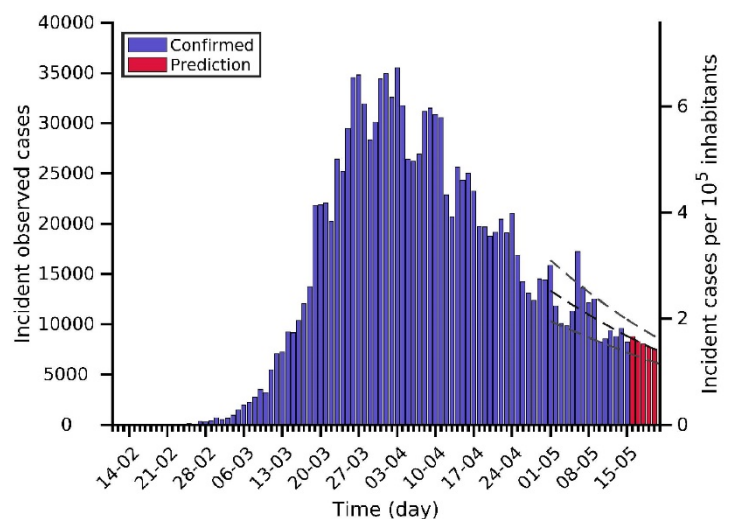
Attack rate and short-term predictions in EU+EFTA+UK

Short-term predictions, based on last 15 points with increased weight on last 3:



Highlights and/or warnings

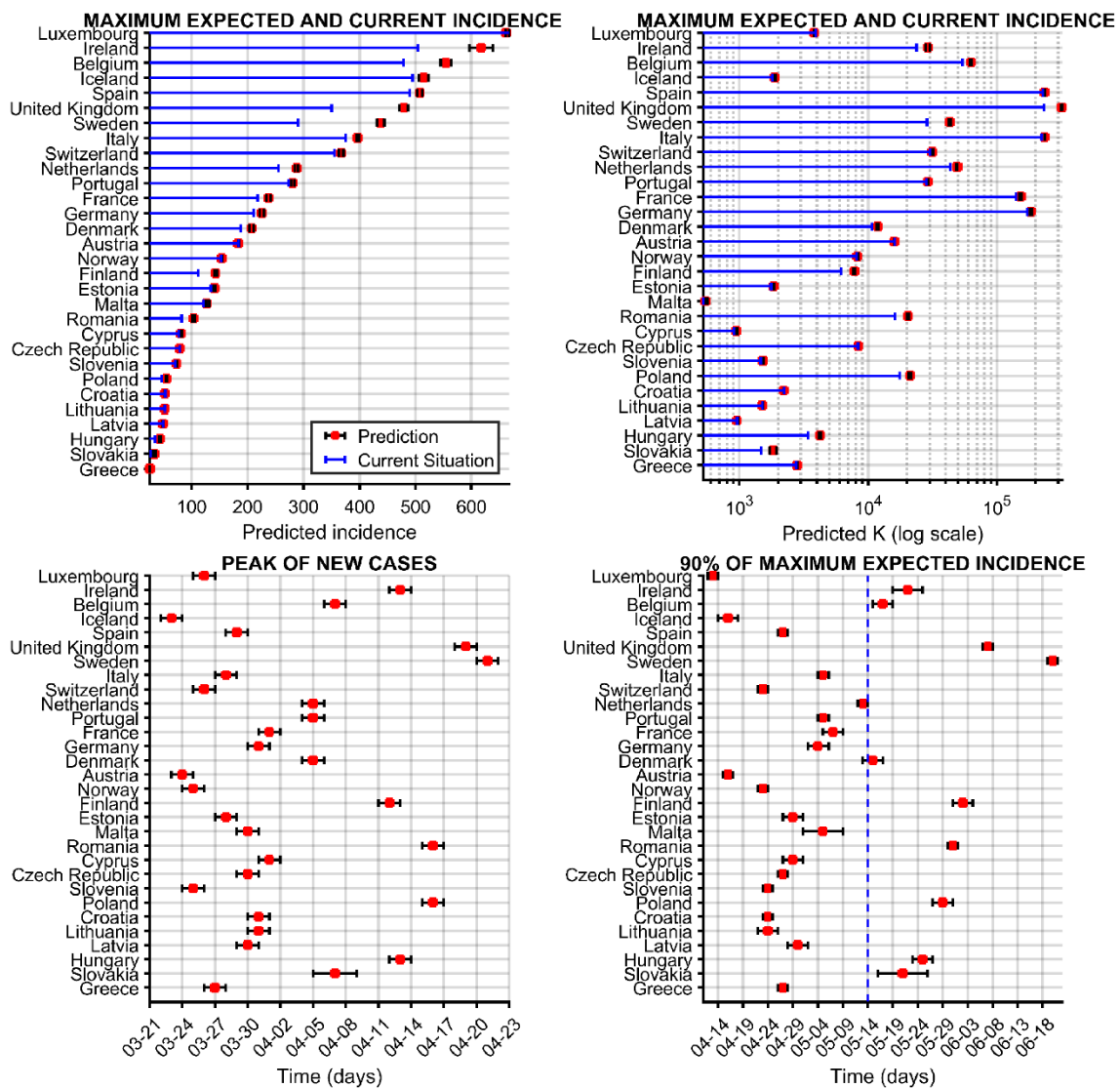
- UE+EFTA+UK new cases are shown in the figure. They are currently at the level of 9,000.
- Sweden and United Kingdom are the countries at highest risk ($EPG_{REP} > 70$).
- All countries maintain trends from previous days.
- There are several countries at $p_7 \geq 1$ but with low A_{14} (see table). These cases are not worrying if a significant increase is not observed in the next days.



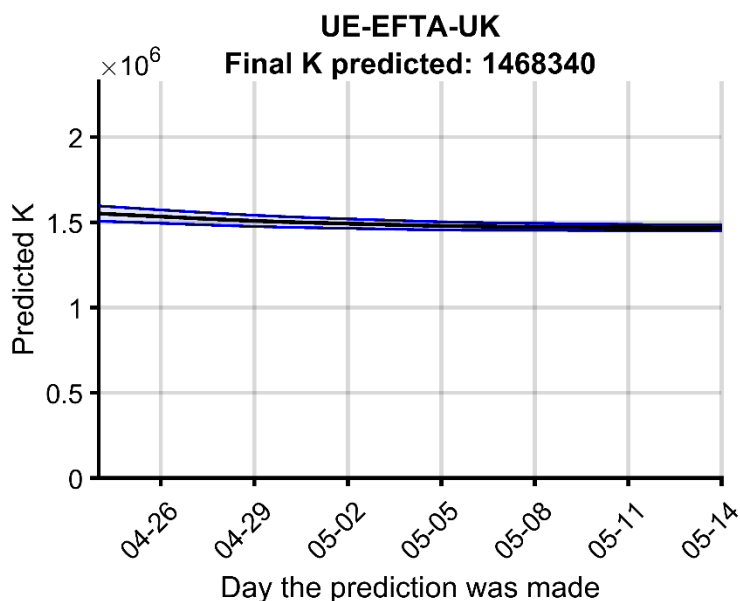
Long-term predictions

Long-term predictions, evaluated with the **whole historical series**. See figure in the next page. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current

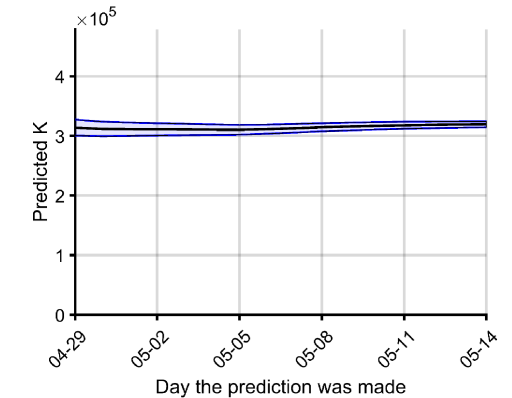
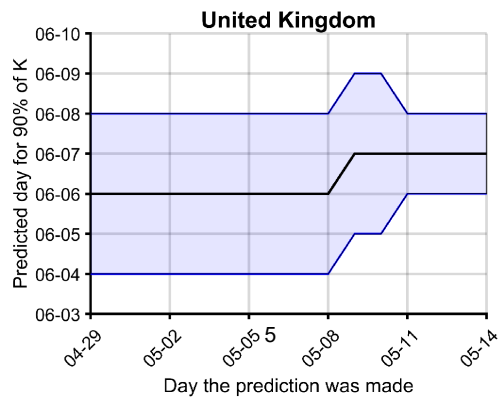
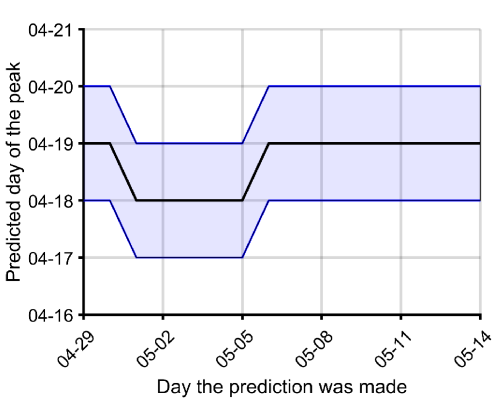
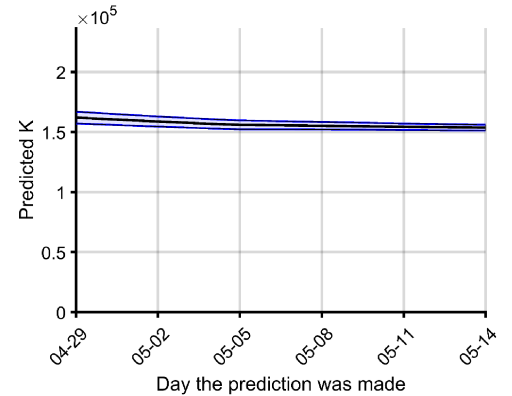
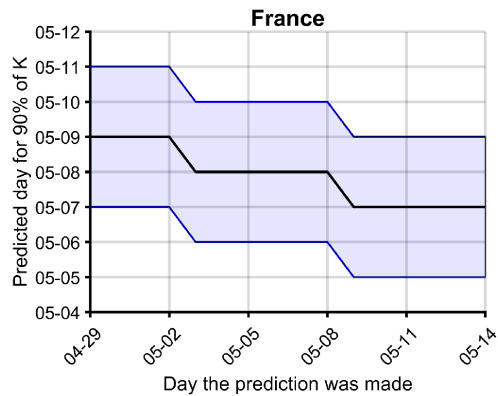
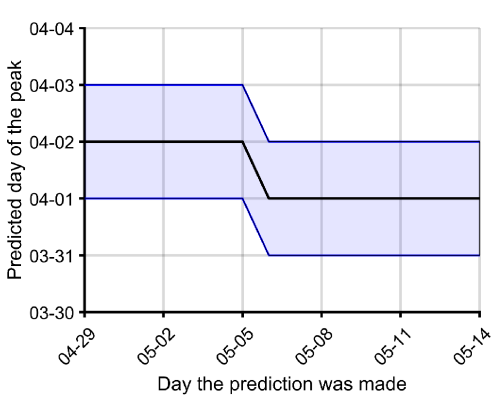
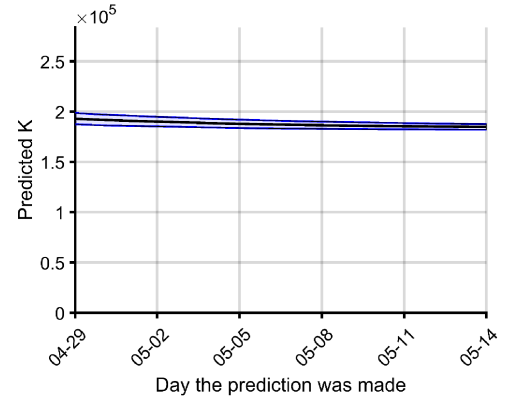
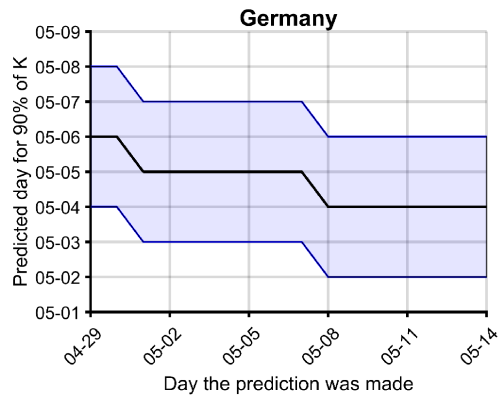
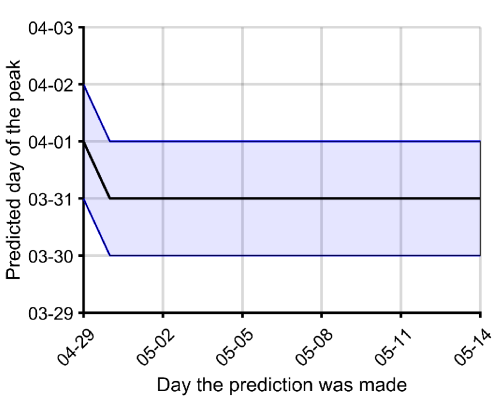
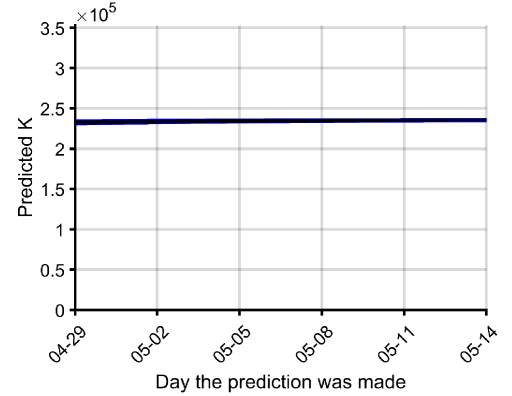
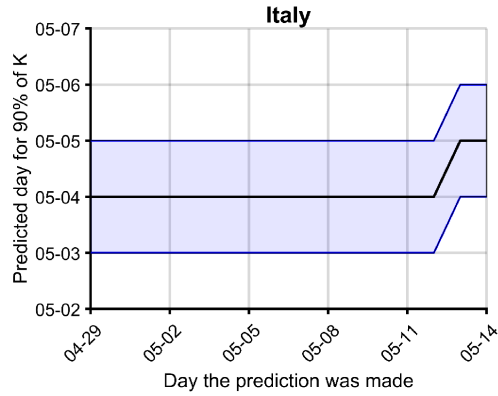
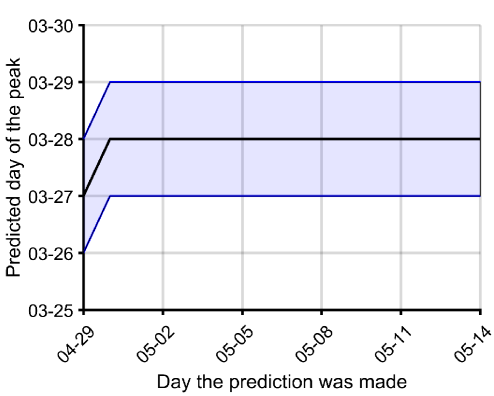
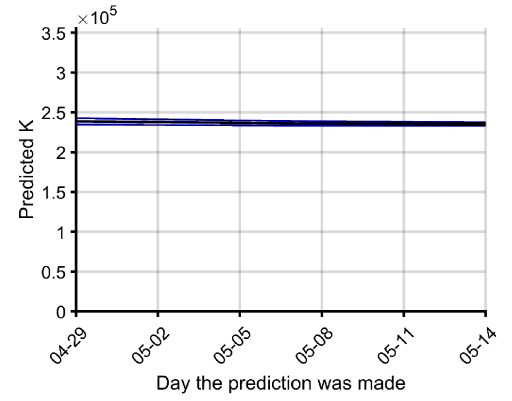
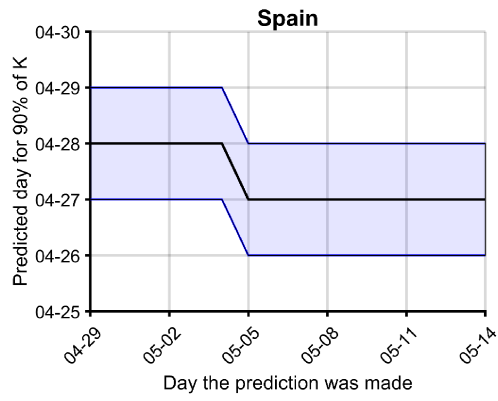
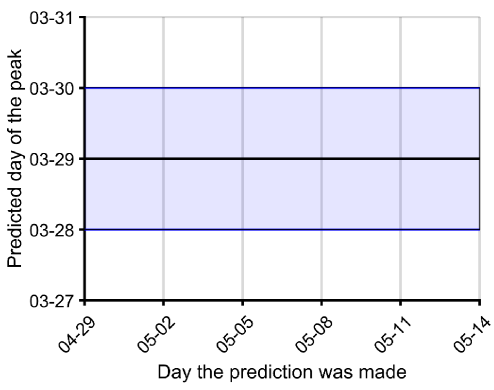
situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown.



2020-05-14



Situation and trends per country

Maps. The map in the left shows current A_{14} . The map in the right shows current EPG .

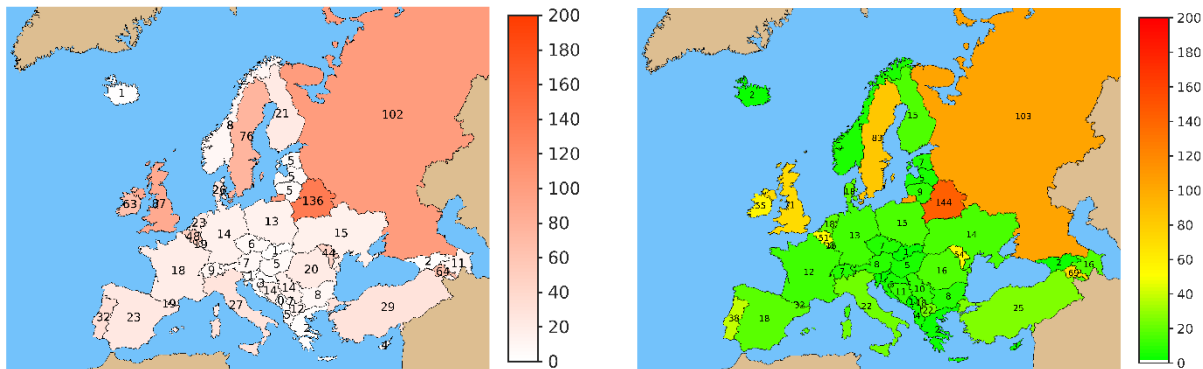


Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
United Kingdom	236.711	356,3	33.998	51,2	59.257	89,2	0,82	73	1.099
Spain	230.183	496,6	27.459	59,2	10.869	23,5	0,76	18	216
Italy	223.885	376,7	31.610	53,2	16.457	27,7	0,80	22	314
Germany	173.772	212,1	7.881	9,6	12.069	14,7	0,90	13	66
France	141.919	219,3	27.529	42,5	11.734	18,1	0,68	12	245
Belgium	54.644	481,1	8.959	78,9	5.612	49,4	1,06	52	877
Netherlands	43.681	257,1	5.643	33,2	3.890	22,9	0,81	19	244
Switzerland	30.431	355,1	1.594	18,6	809	9,4	0,76	7	38
Sweden	29.207	296,9	3.646	37,1	7.687	78,1	1,09	85	1.199
Portugal	28.583	275,6	1.190	11,5	3.232	31,2	1,20	37	172
Ireland	23.956	506,9	1.518	32,1	3.123	66,1	0,87	58	370
Poland	18.016	47,1	907	2,4	4.911	12,8	1,13	15	88
Romania	16.437	83,1	1.056	5,3	3.870	19,6	0,77	15	109
Austria	16.068	184,4	628	7,2	610	7,0	1,18	8	33
Denmark	10.791	188,9	537	9,4	1.480	25,9	0,69	18	92
Czech Republic	8.406	79,2	295	2,8	669	6,3	1,07	7	26
Norway	8.197	152,7	232	4,3	438	8,2	0,66	5	16
Finland	6.228	113,2	293	5,3	1.177	21,4	0,72	15	80
Luxembourg	3.923	681,1	104	18,1	121	21,0	0,83	18	44
Hungary	3.473	35,6	448	4,6	531	5,4	0,93	5	73
Greece	2.810	25,1	160	1,4	219	2,0	1,16	2	14
Croatia	2.222	52,7	95	2,3	137	3,3	1,45	5	NA
Bulgaria	2.138	30,0	102	1,4	550	7,7	1,00	8	43
Iceland	1.802	494,7	10	2,7	4	1,1	0,57	1	NA
Estonia	1.766	134,6	63	4,8	72	5,5	1,22	7	NA
Lithuania	1.523	52,4	54	1,9	124	4,3	1,99	8	NA
Slovakia	1.480	27,2	27	0,5	77	1,4	0,89	1	NA
Slovenia	1.465	70,5	103	5,0	31	1,5	0,96	1	11
Latvia	970	49,2	19	1,0	100	5,1	0,90	5	NA
Cyprus	910	77,8	17	1,5	53	4,5	0,69	3	NA
Malta	532	124,0	6	1,4	65	15,2	NA	NA	NA
Liechtenstein	83	215,3	1	2,6	0	0,0	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	200	2000
Best	Best	Best	Best	Best	Best	Best	0,0	0	0

⁽¹⁾ ρ_7 is the average of 7 consecutive ρ , but can still fluctuate. ^(2,3) EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_7 .

Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	83	11	16
Germany	77	12	17
France	76	10	20
Spain	75	8	12
Belgium	71	11	14
Netherlands	71	11	20
Sweden	71	10	28
Austria	69	10	14
Denmark	68	4	30
Czech Republic	65	11	NA
Finland	65	12	46
Greece	65	18	NA
Iceland	65	5	15
Portugal	64	9	15
Slovenia	64	6	NA
Estonia	63	5	30
Ireland	63	8	18
Poland	63	17	NA
Romania	63	15	NA
Luxembourg	60	6	7
Slovakia	59	24	NA
Bulgaria	58	30	NA
Croatia	58	12	NA
Hungary	57	20	NA
Latvia	57	12	NA
Lithuania	56	9	NA
Malta	55	9	35
Cyprus	54	12	NA

Situation, trends and long-term predictions in Italian and Spanish regions

Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Lombardia	84,518	841.7	15,450	153.9	7,516	74.8	0.88	66	1,232
Piemonte	29,483	676.8	3,594	82.5	2,304	52.9	0.80	43	548
Emilia Romagna	27,182	609.5	3,960	88.8	1,332	29.9	0.65	20	291
Veneto	18,928	385.8	1,783	36.3	704	14.4	0.69	10	99
Toscana	9,913	265.8	979	26.2	388	10.4	0.84	9	92
Liguria	9,111	587.6	1,346	86.8	799	51.5	0.92	48	762
Lazio	7,396	125.8	616	10.5	640	10.9	0.80	9	77
Marche	6,642	435.5	982	64.4	344	22.6	0.76	17	257
Campania	4,668	80.5	396	6.8	209	3.6	0.87	3	27
Puglia	4,374	108.6	463	11.5	241	6.0	0.76	5	50
Trento	4,326	403.4	453	42.2	145	13.5	0.80	11	220
Sicilia	3,382	67.6	265	5.3	169	3.4	0.82	3	22
Friuli Venezia Giulia	3,183	261.9	319	26.3	124	10.2	0.95	10	101
Abruzzo	3,178	242.3	383	29.2	214	16.3	0.79	13	156
Bolzano	2,578	2,399.6	290	269.9	43	40.0	0.87	35	85
Umbria	1,422	161.2	73	8.3	28	3.2	1.10	3	NA
Sardegna	1,352	82.5	125	7.6	37	2.3	1.54	3	34
Valle d'Aosta	1,173	933.9	142	113.1	37	29.5	1.30	38	462
Calabria	1,151	59.1	95	4.9	39	2.0	1.14	2	NA
Molise	410	134.2	22	7.2	109	35.7	2.02	72	NA
Basilicata	390	69.3	27	4.8	10	1.8	NA	NA	NA

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	Best	Best	Best	0.0	0

Spain

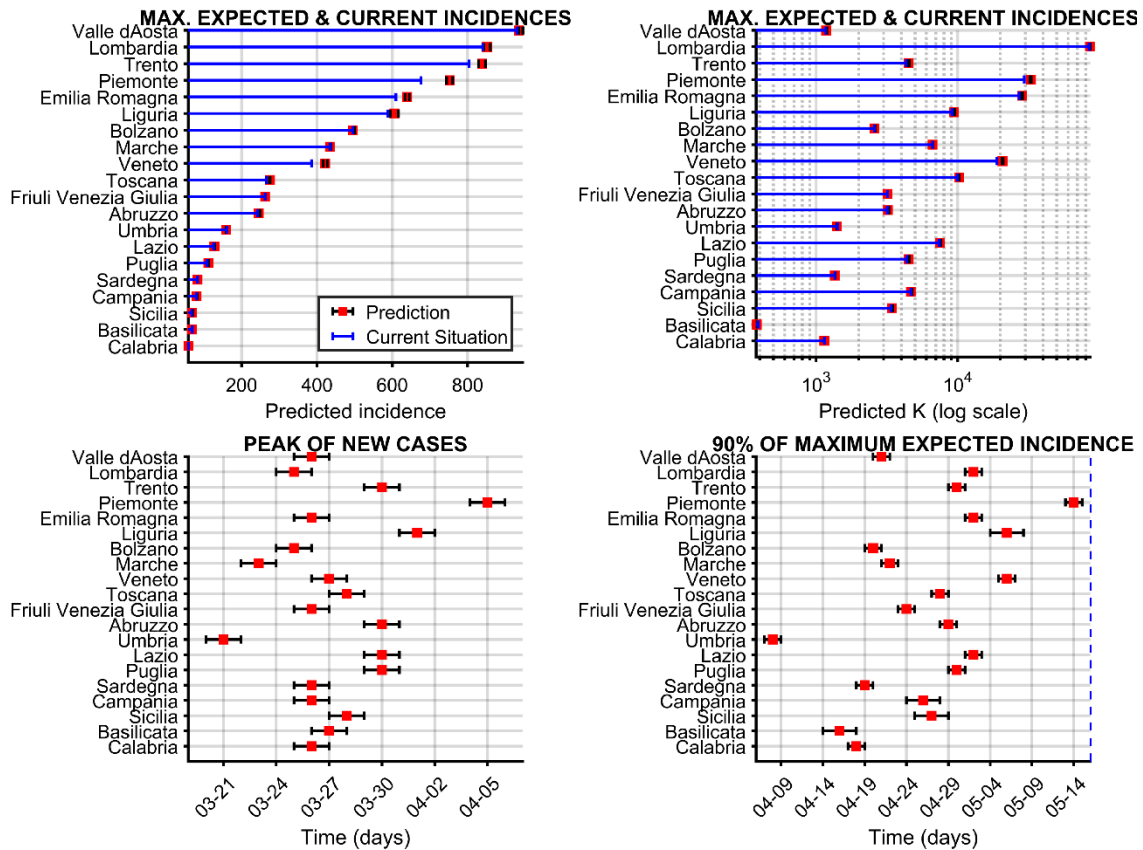
Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulated deaths	Mortality rate / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Madrid	66,043	994.5	8,826	132.9	2,444	36.8	0.71	26	356
Catalunya	53,034	701.0	5,915	78.2	3,184	42.1	0.7	28	324
Castilla y Leon	18,369	762.8	1,940	80.6	1,204	50.0	0.87	44	478
Castilla-La Mancha	16,587	814.9	2,883	141.6	620	30.5	0.9	28	501
Euskadi	13,291	610.2	1,455	66.8	404	18.5	0.85	16	179
Andalucia	12,420	147.4	1,355	16.1	315	3.7	1.26	5	54
Comunitat Valenciana	10,850	218.1	1,365	27.4	439	8.8	0.75	7	86
Galicia	9,328	345.4	604	22.4	426	15.8	0.48	8	51
Aragon	5,456	413.1	838	63.4	320	24.2	1.01	24	385
Navarra	5,137	790.3	501	77.1	249	38.3	0.77	29	305
La Rioja	4,020	1,282.0	348	111.0	73	23.3	0.48	11	100
Extremadura	2,958	277.6	497	46.7	134	12.6	0.77	10	165
Asturias	2,366	231.4	313	30.6	55	5.4	1.17	6	84
Canarias	2,284	103.5	151	6.8	72	3.3	1.20	4	26
Cantabria	2,265	389.4	206	35.4	64	11.0	1.18	13	129
Baleares	1,982	166.9	216	18.2	80	6.7	1.00	7	80
Murcia	1,542	103.7	144	9.7	51	3.4	1.79	6	59
Melilla	119	140.5	2	2.4	4	4.7	NA	NA	NA
Ceuta	116	136.7	4	4.7	15	17.7	NA	NA	NA

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200
Best	Best	Best	Best	Best	Best	Best	0.0	0

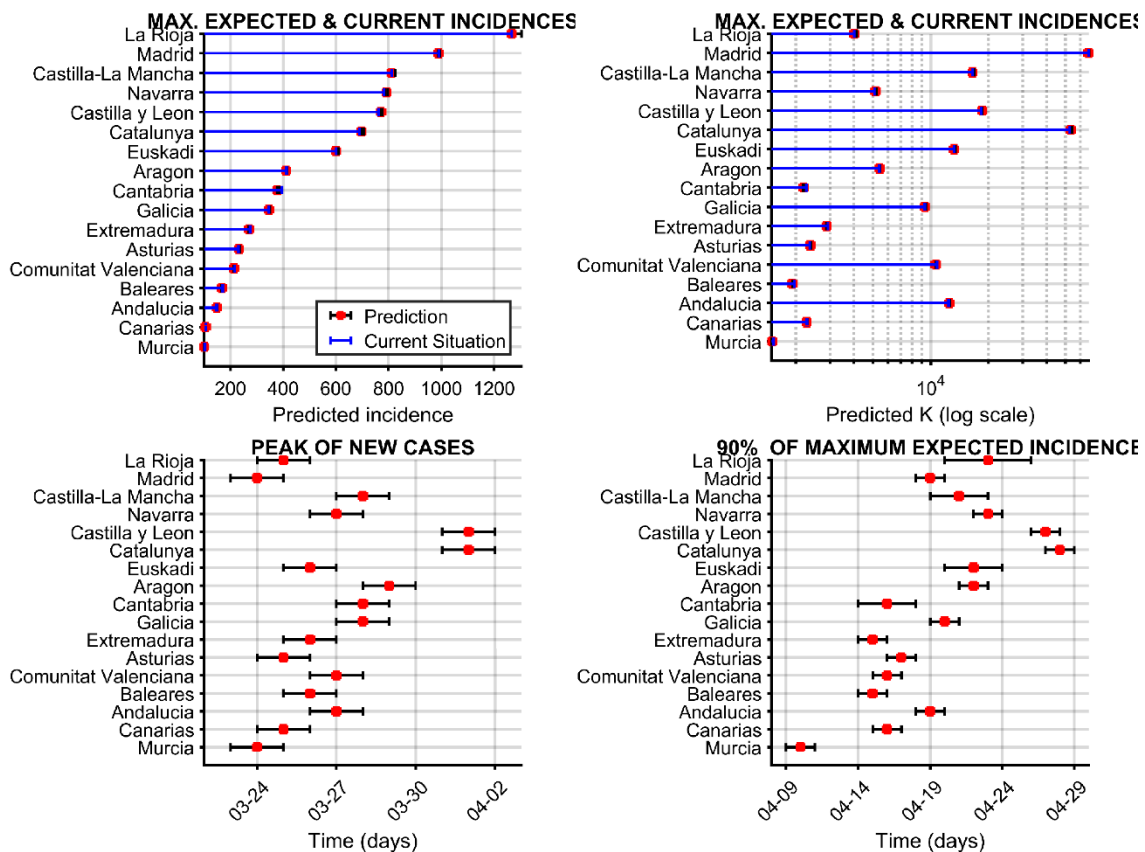
⁽¹⁾ Disclaimer: parameter ρ is very sensitive and experiments daily variations. ρ_7 is the average of 7 consecutive ρ , but can still fluctuate. ^(2,3) EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_7 .

Long-term predictions. Next plots show long-term predictions of: new cases' peaks, final incidence value and approximate date when 90% of total final incidence will be reached. In all three cases we are dealing with the evaluation of global dynamics, which requires small changes in methodology: all data points be used instead of last 15 and with equal weight distribution among them. Blue dashed line indicates current timepoint. See details in Report from 11th April 2020.

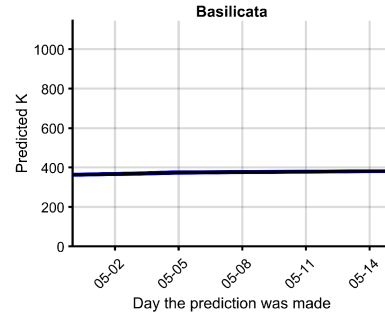
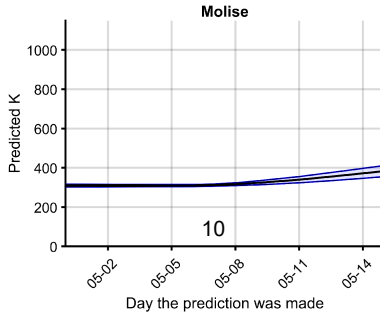
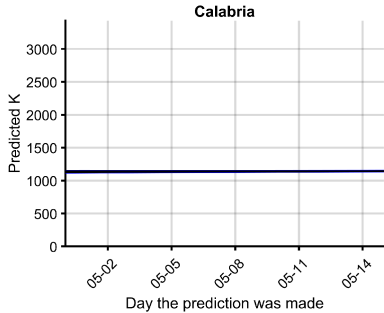
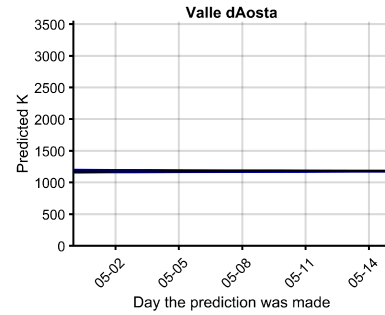
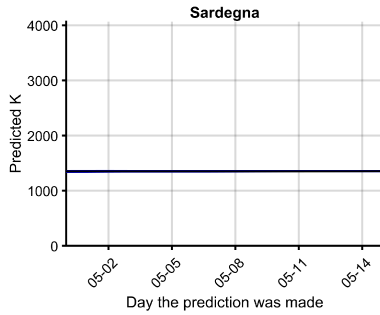
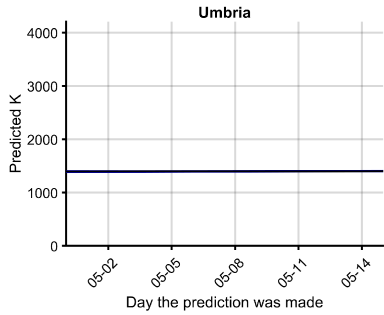
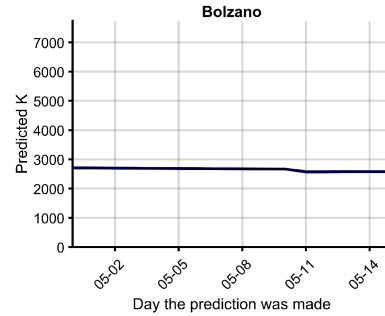
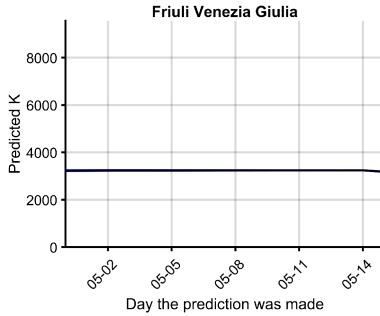
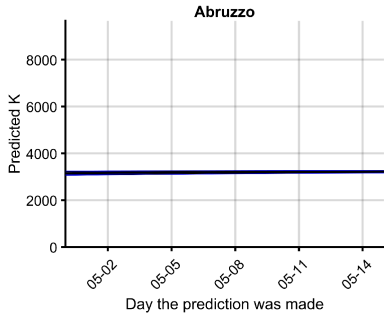
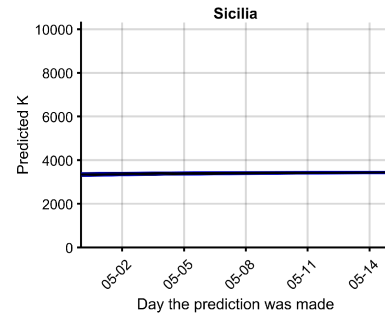
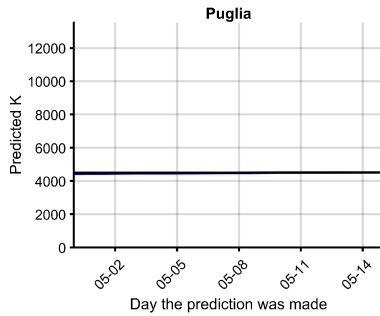
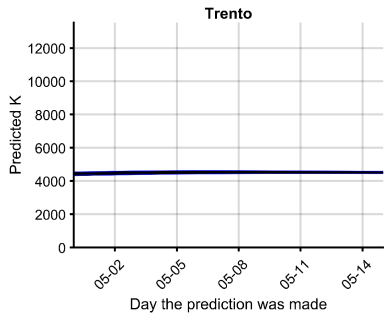
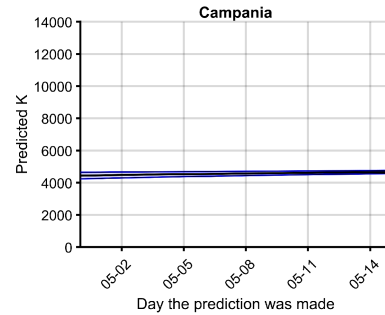
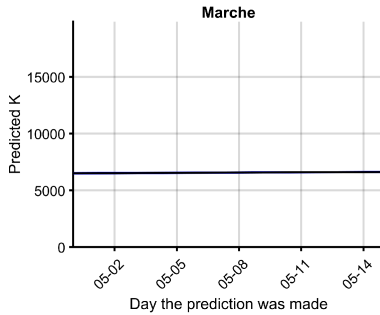
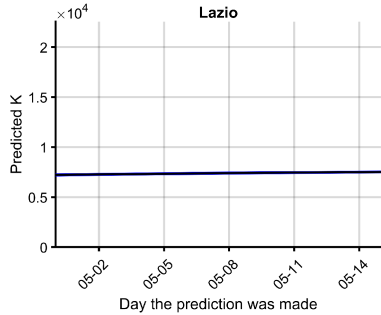
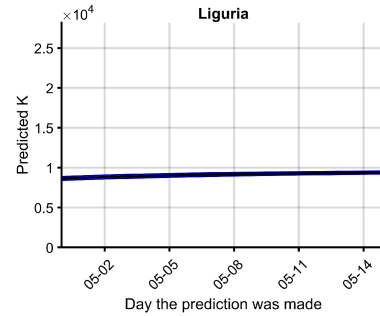
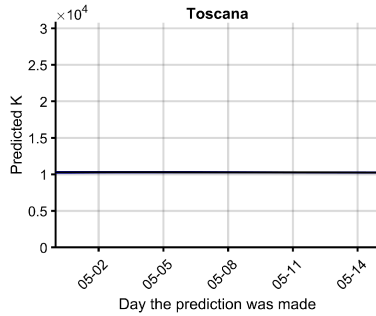
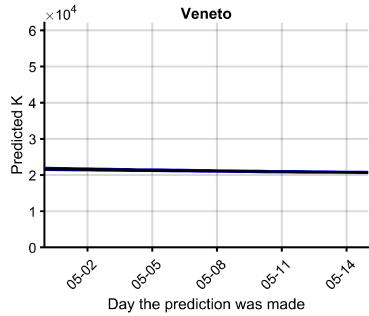
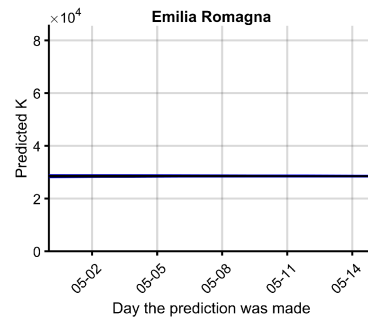
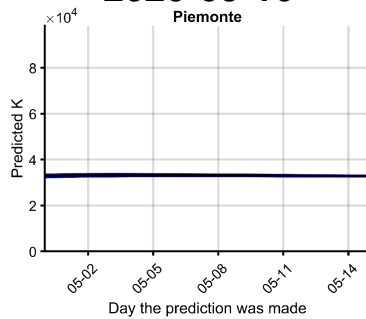
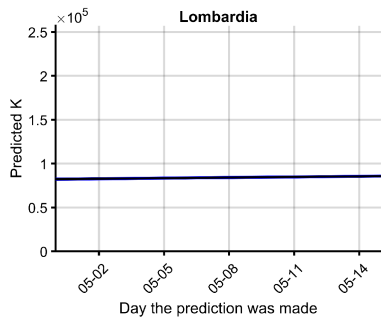
Italy



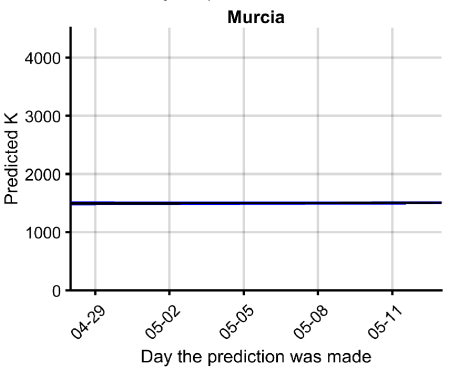
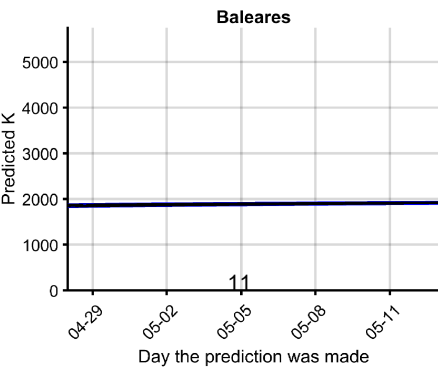
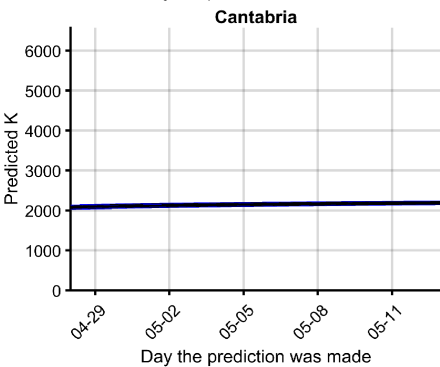
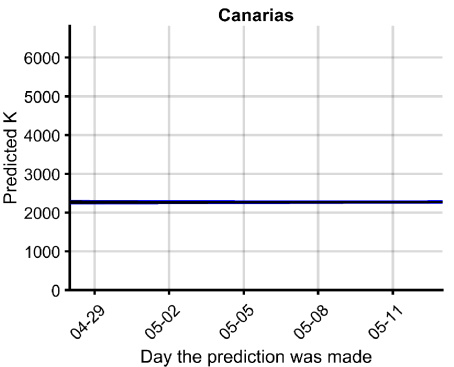
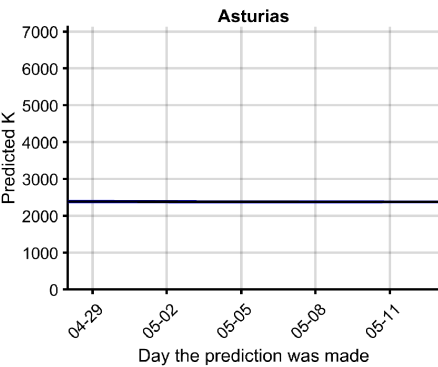
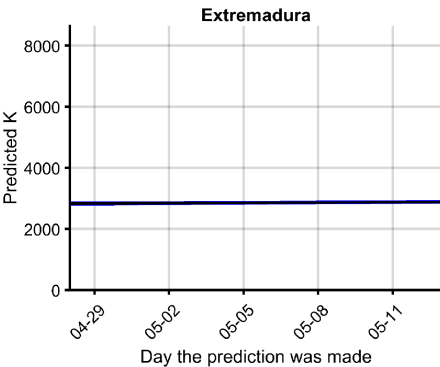
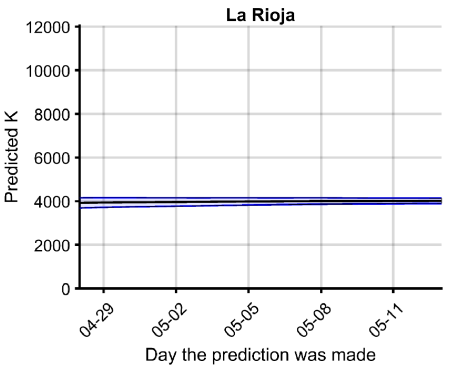
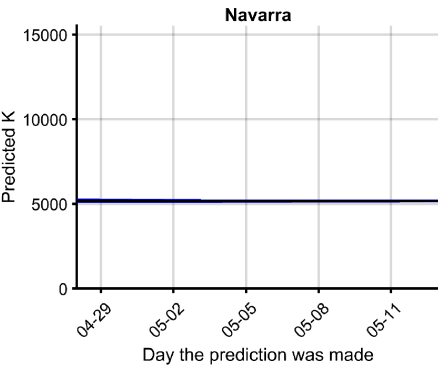
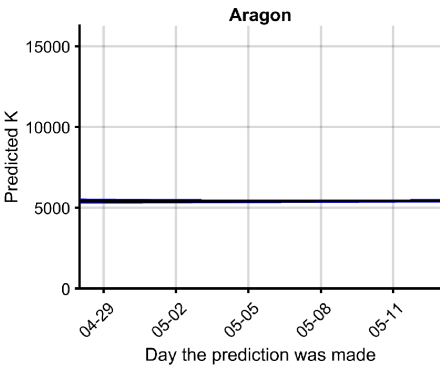
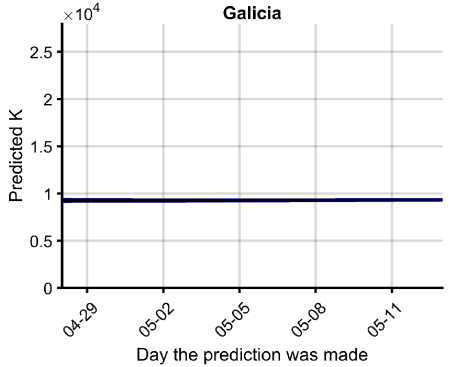
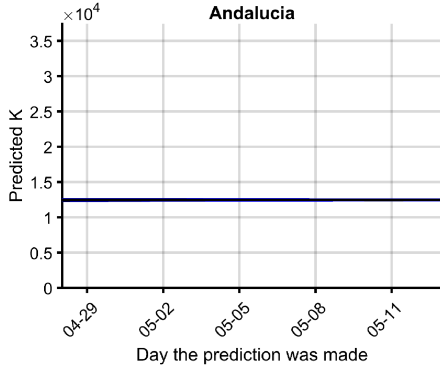
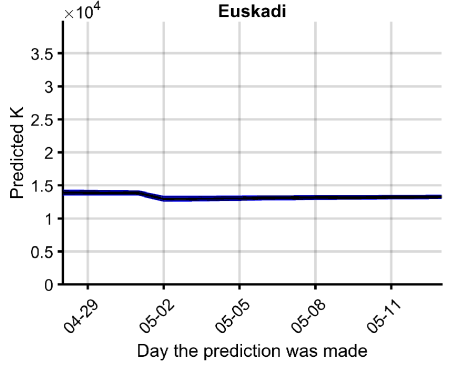
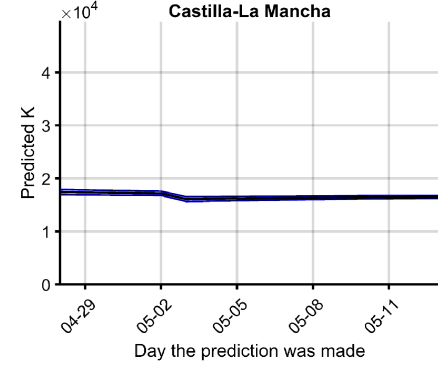
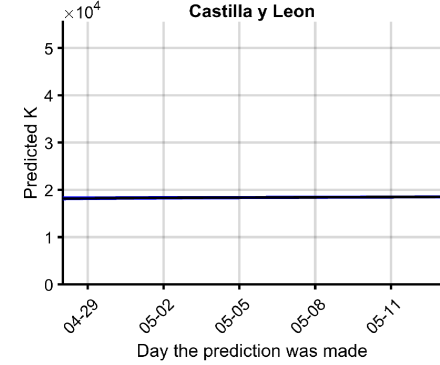
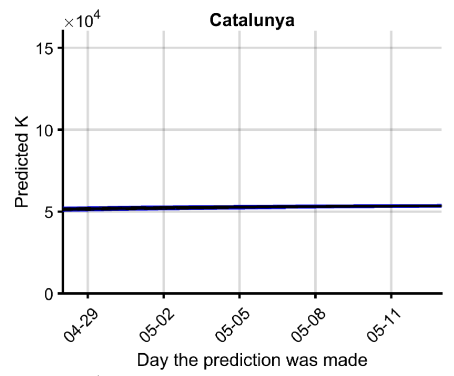
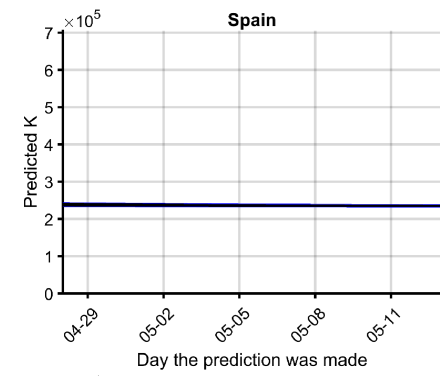
Spain



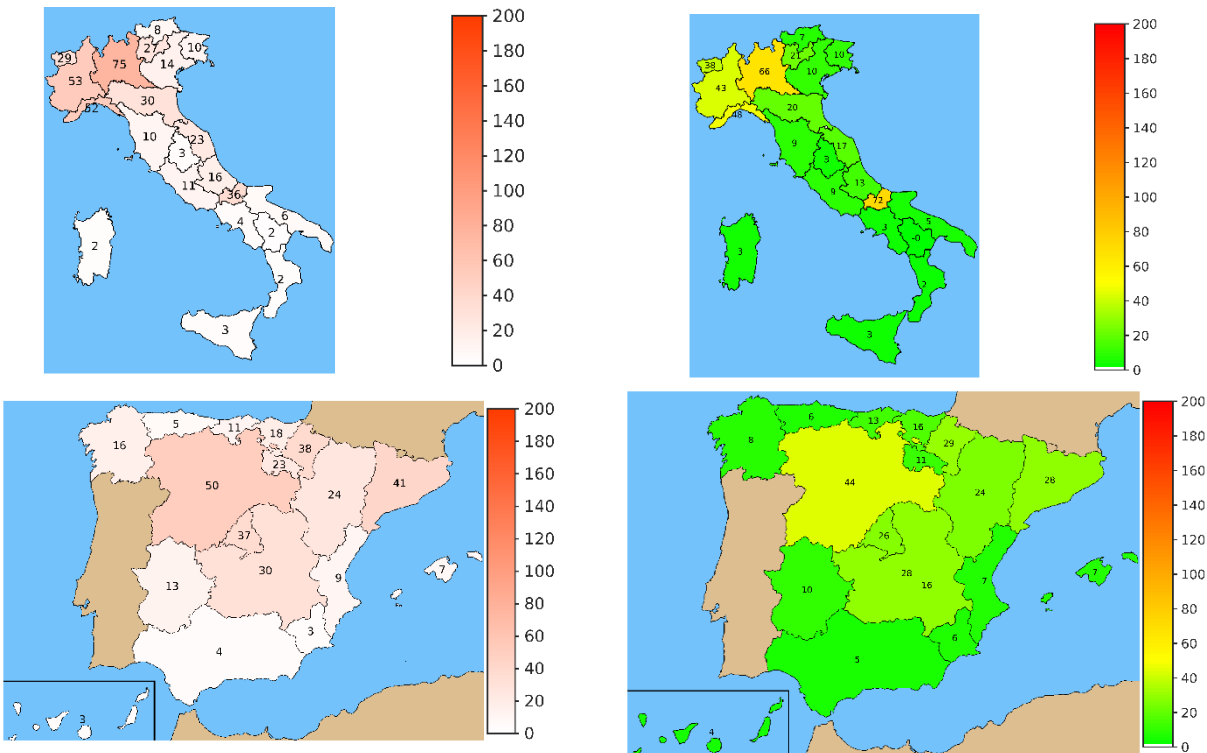
2020-05-16



2020-05-14



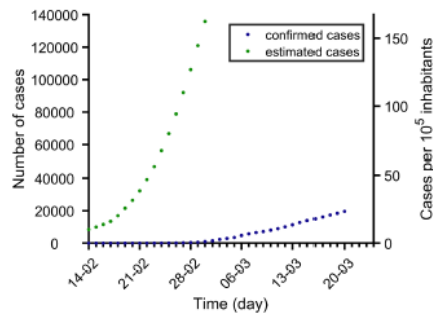
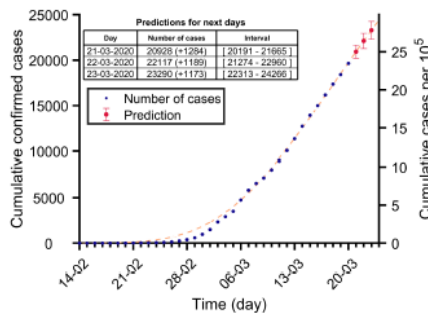
Maps. The maps in the left show current **A₁₄**. The maps in the right show current **EPG**.



Legend: Countries' reports details

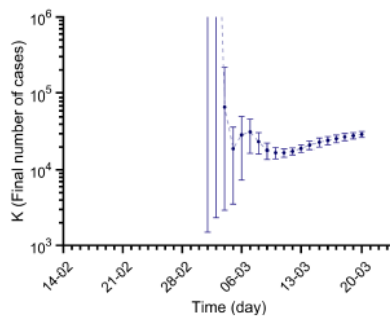
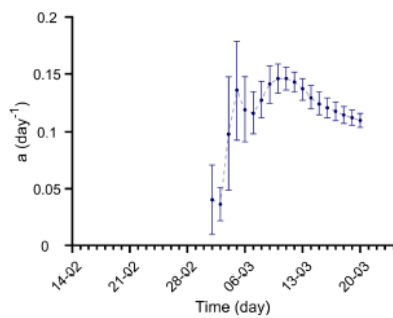
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)



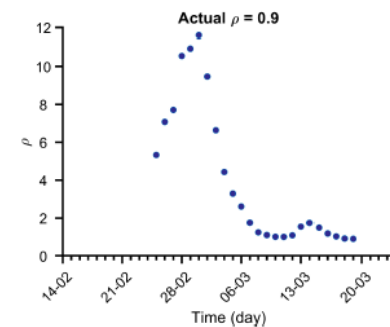
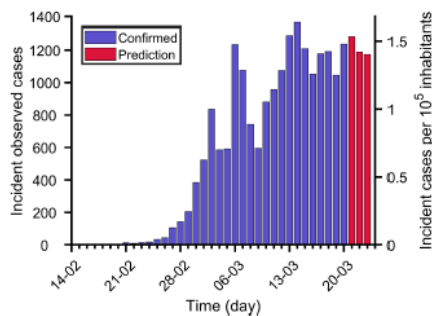
Estimated
cases using
death rate (see
Methods)

Fitted a value
using points
prior to each
date



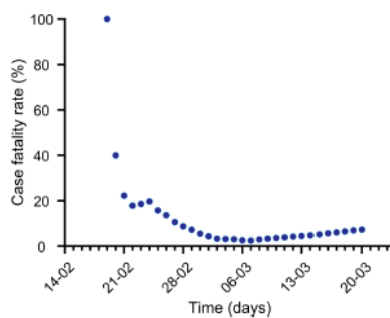
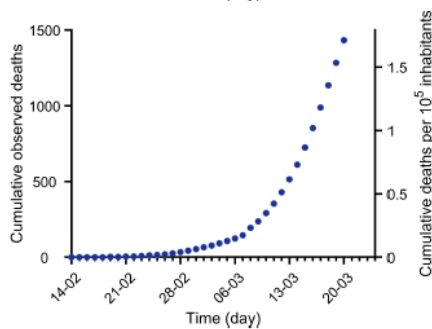
Fitted K value
using points
prior to each
date

Reported
and
predicted
new cases



Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)

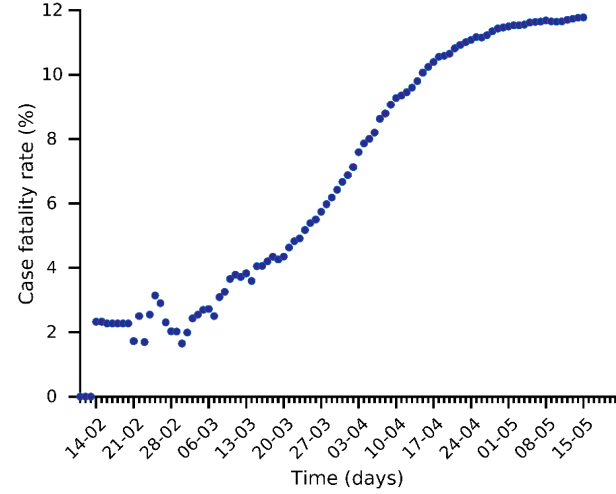
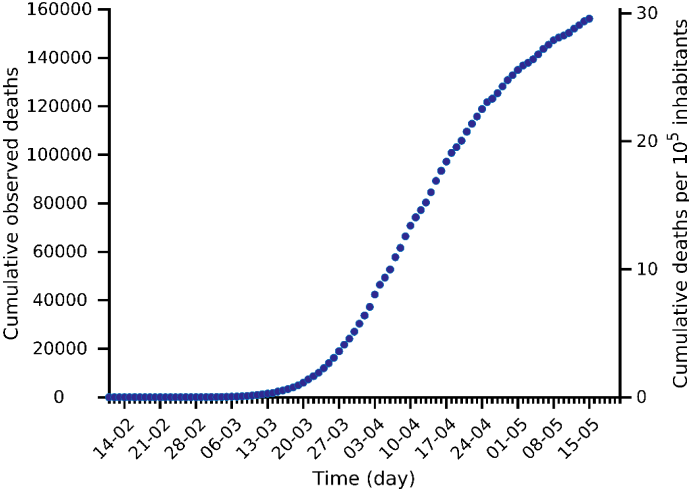
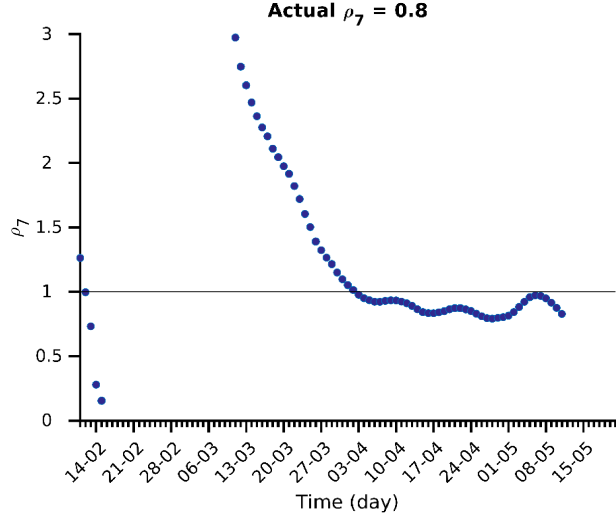
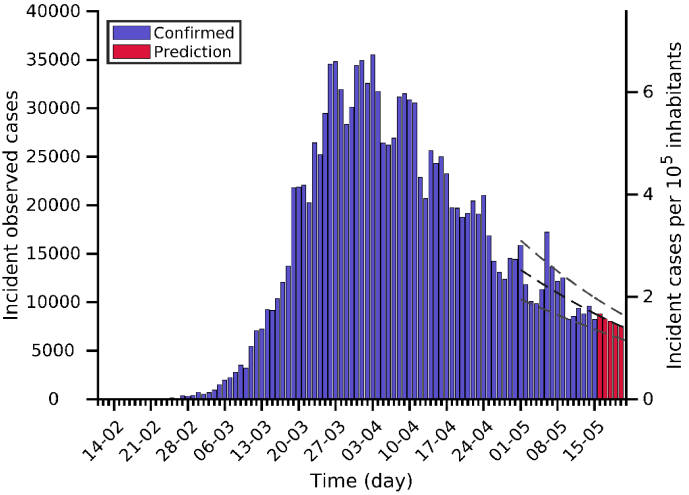
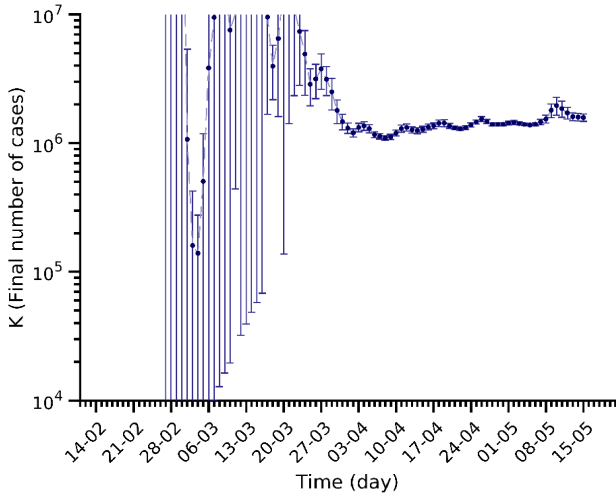
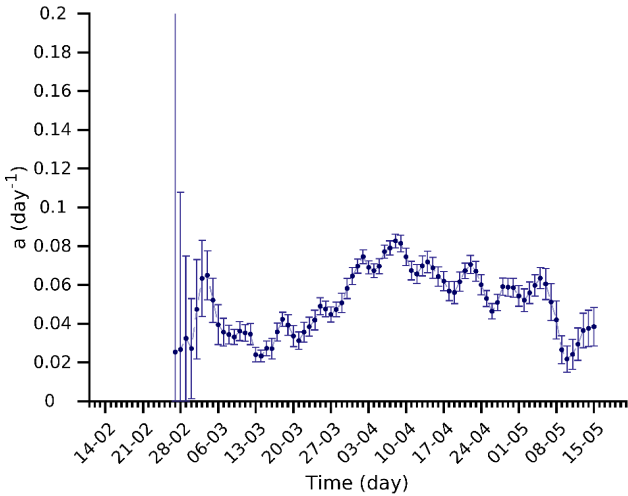
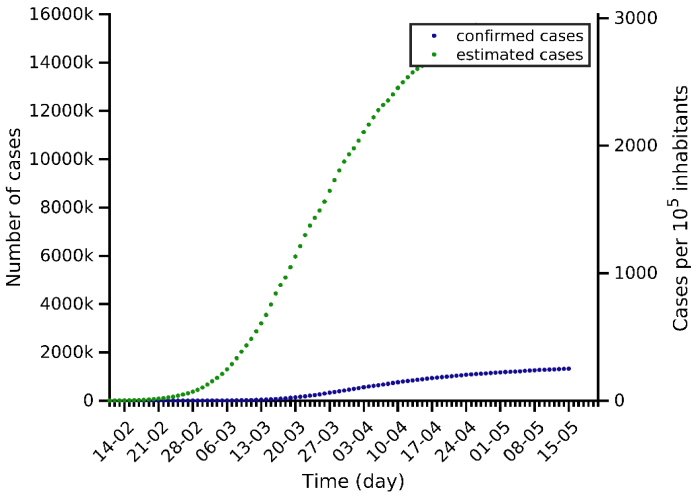
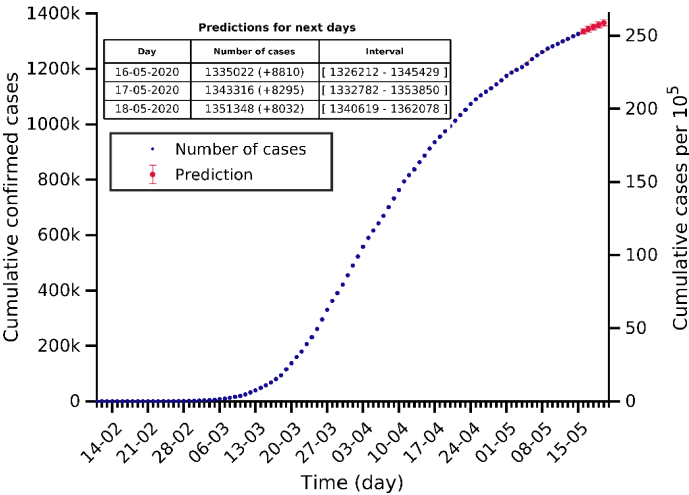
Reported
deaths



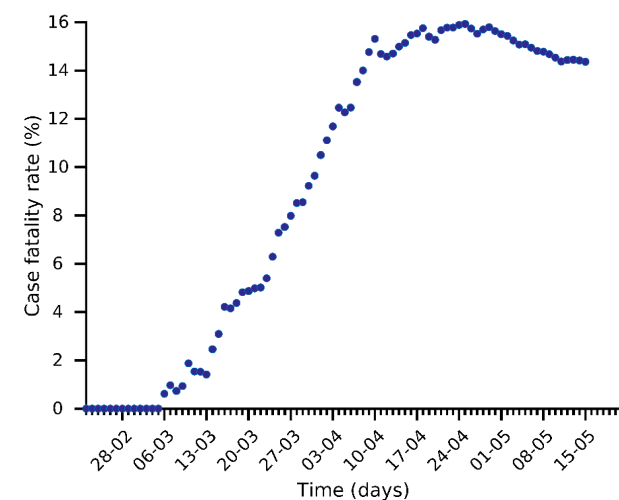
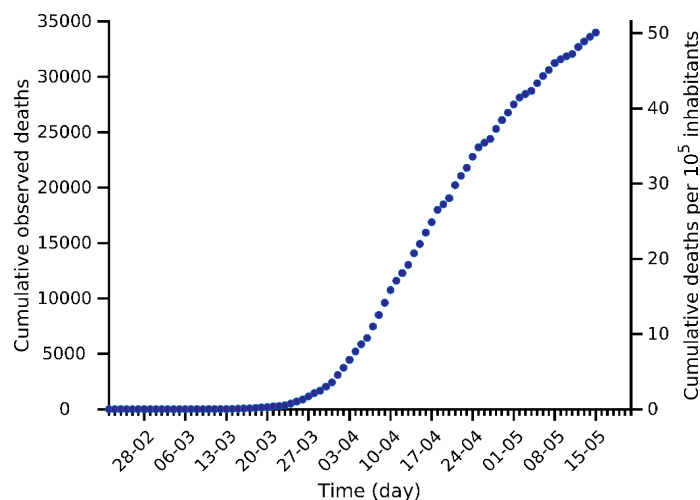
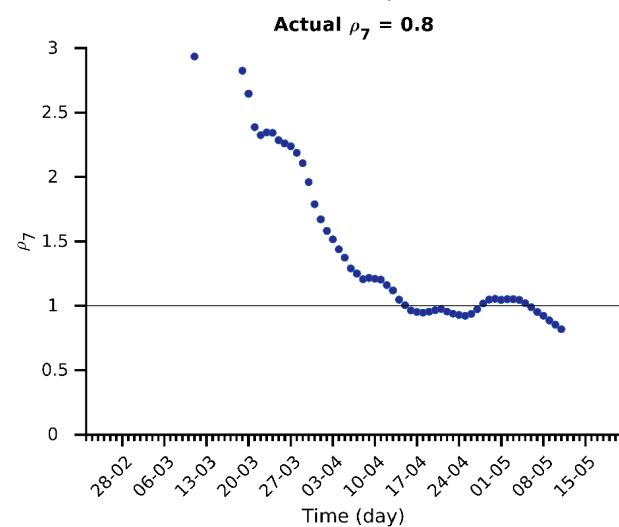
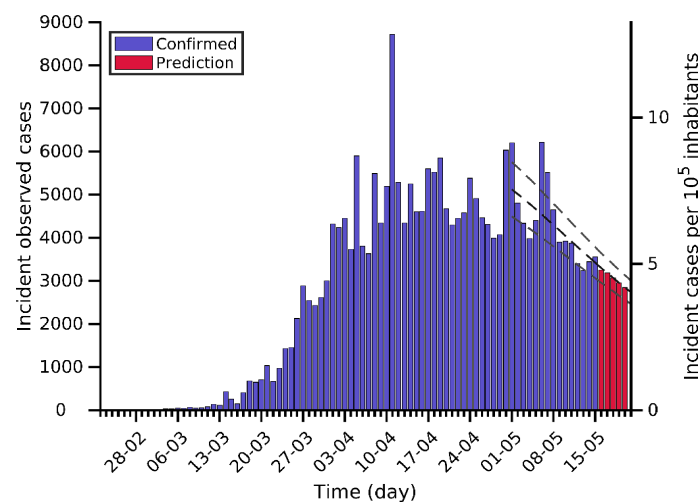
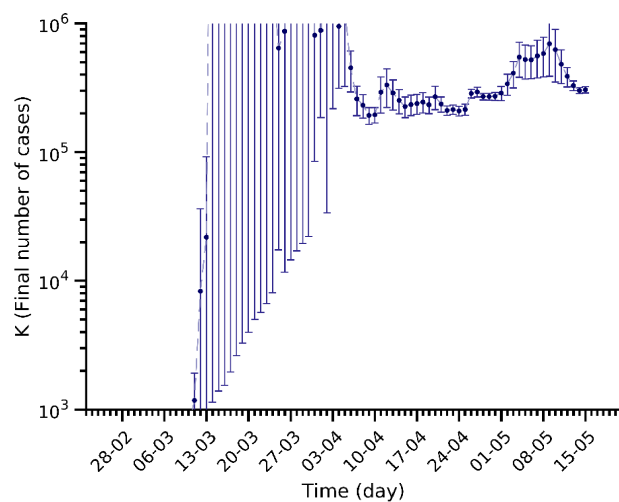
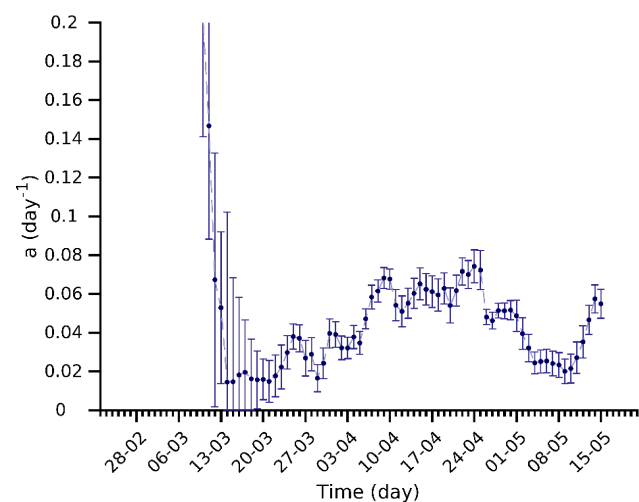
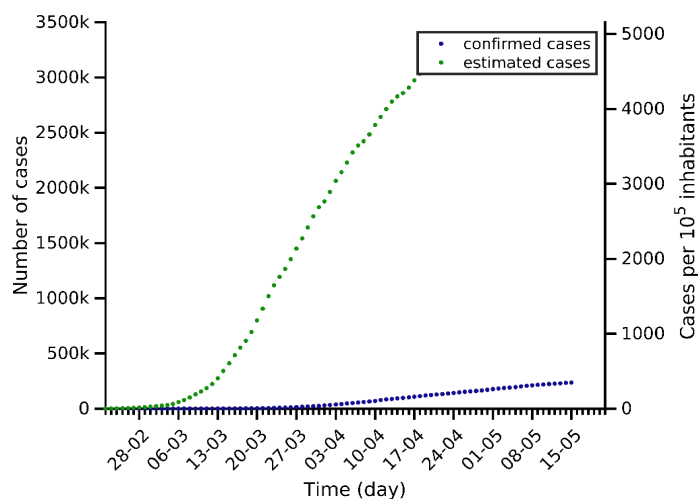
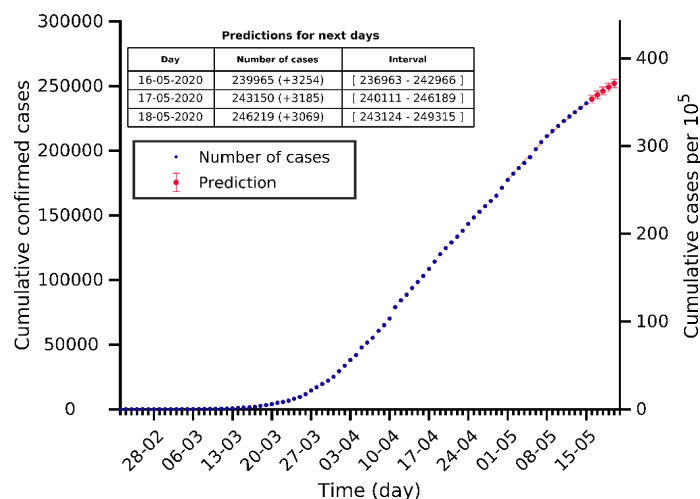
Deaths /
cumulated
reported cases

(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

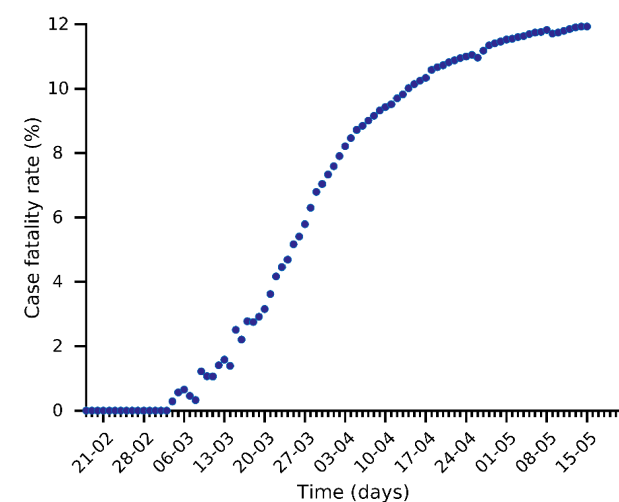
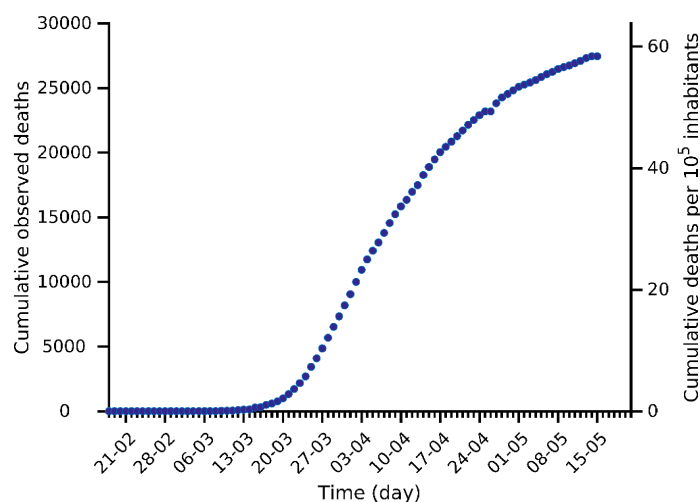
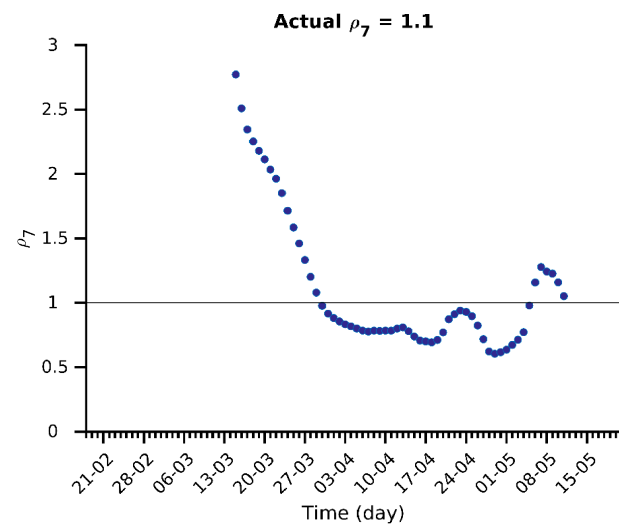
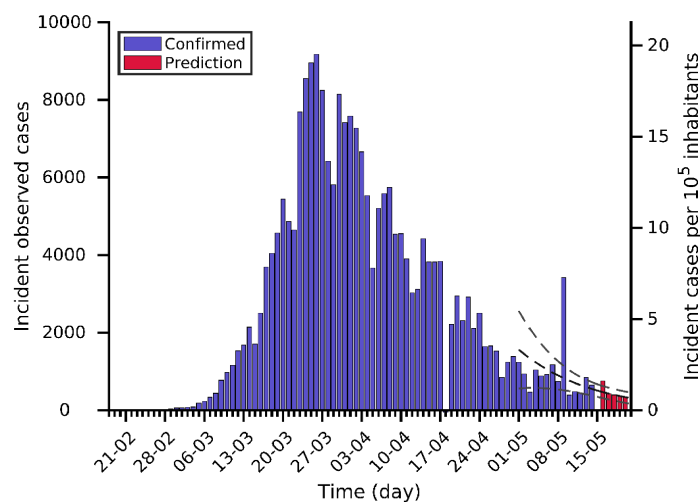
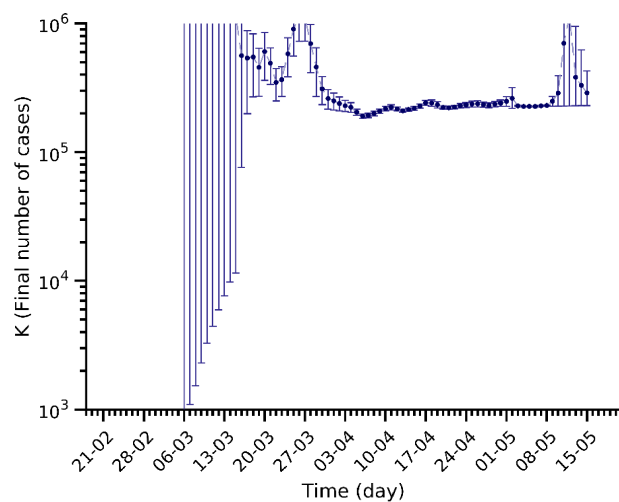
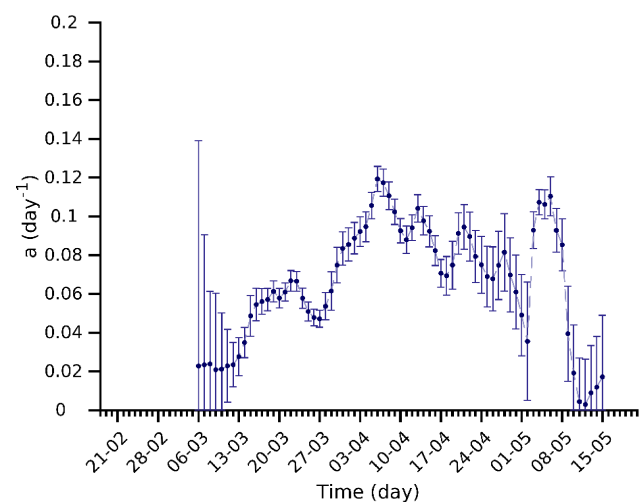
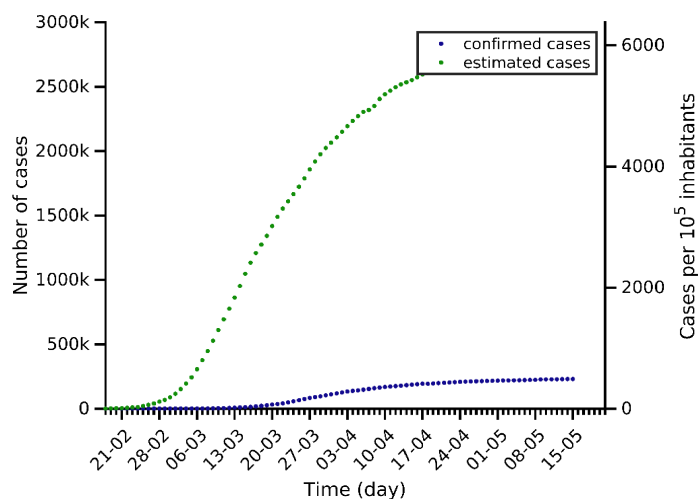
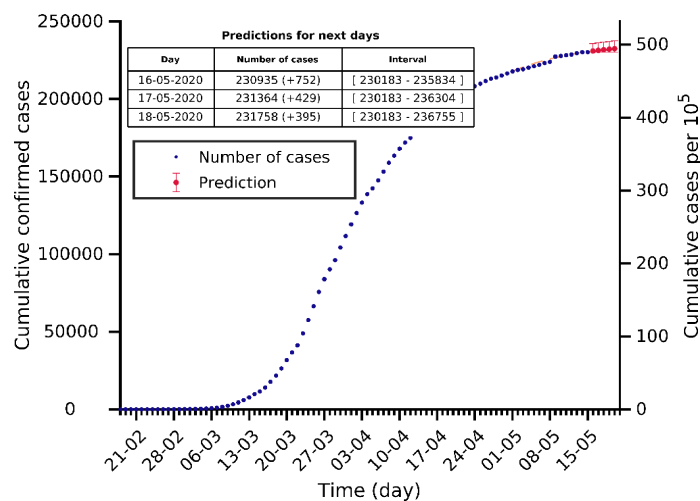
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>



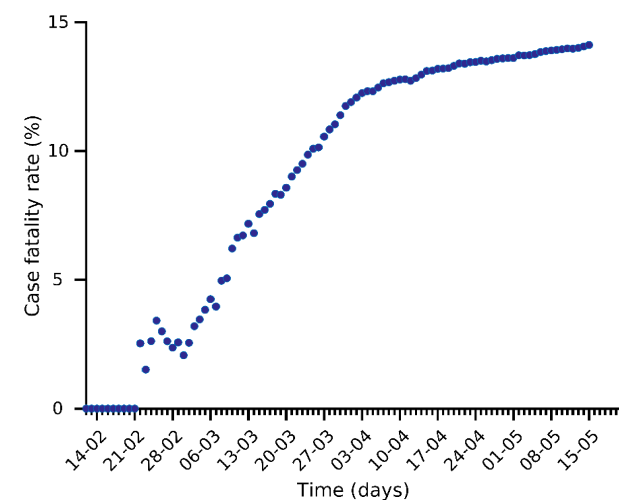
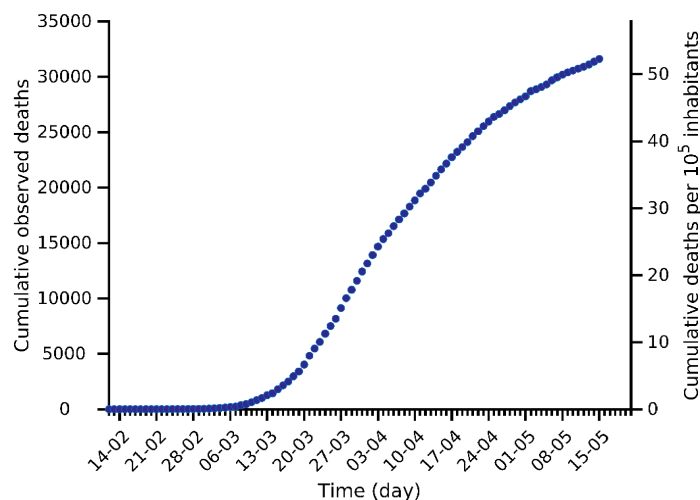
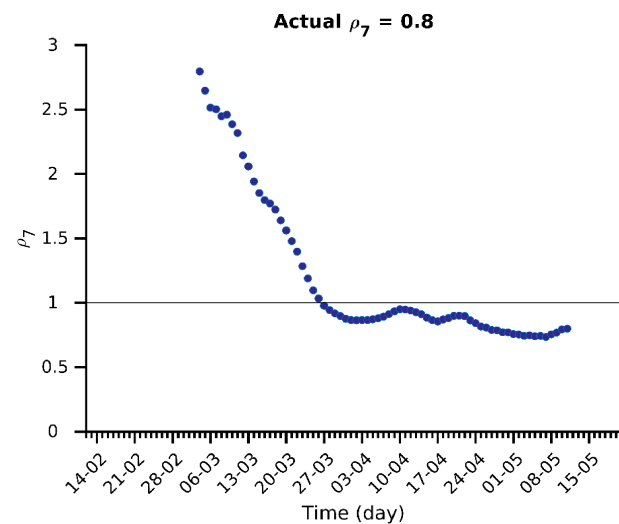
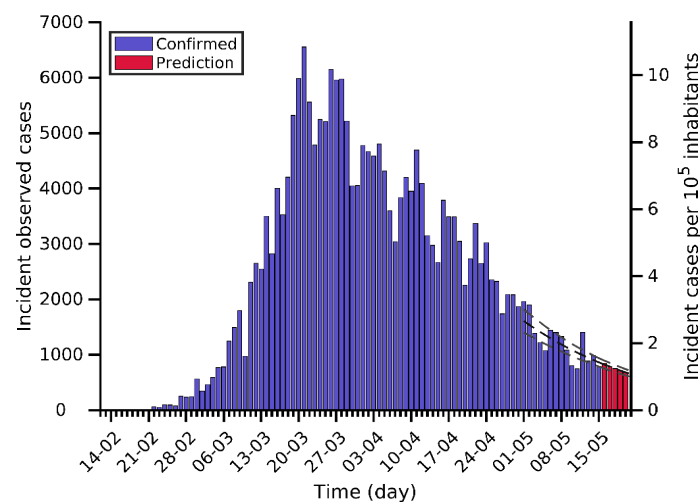
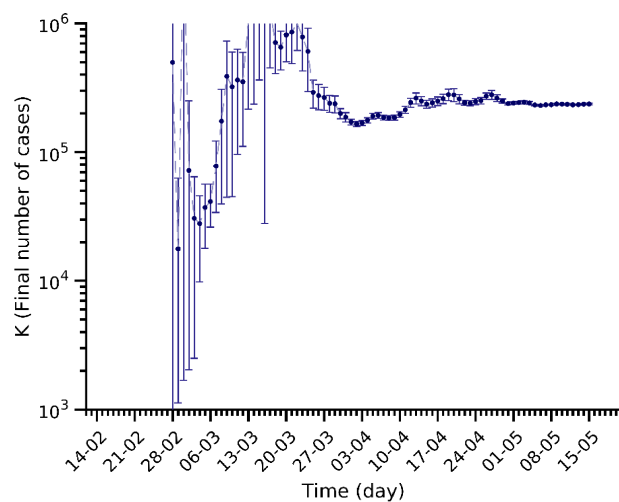
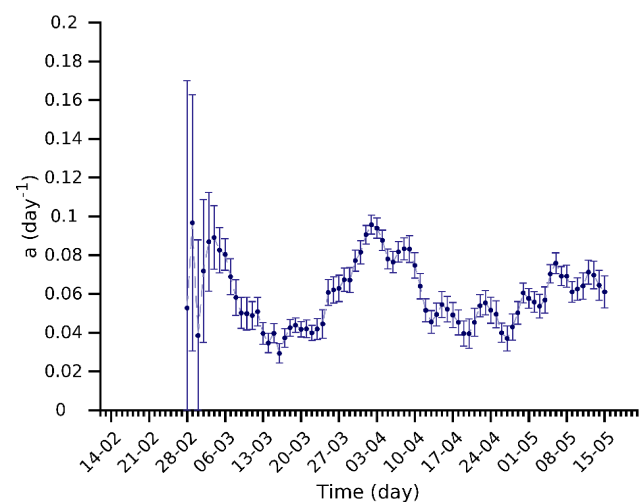
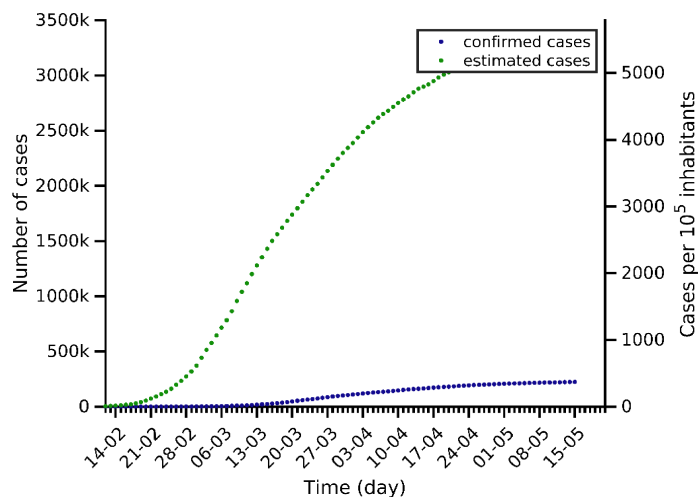
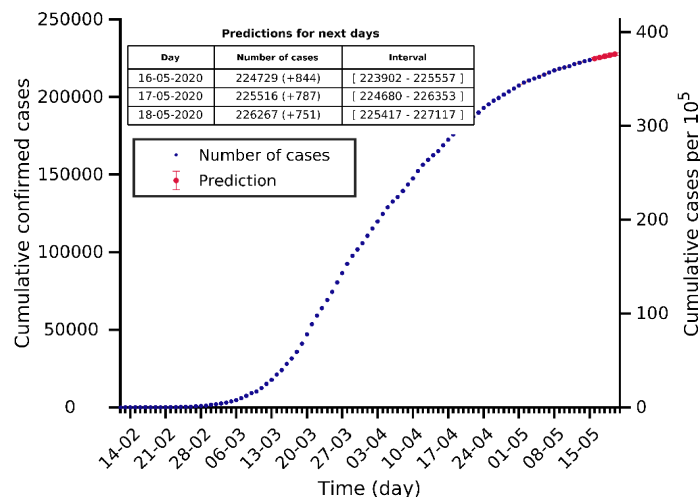
UK 15-05-2020. Population: 67.9M. Current cumulated incidence: 349/10⁵



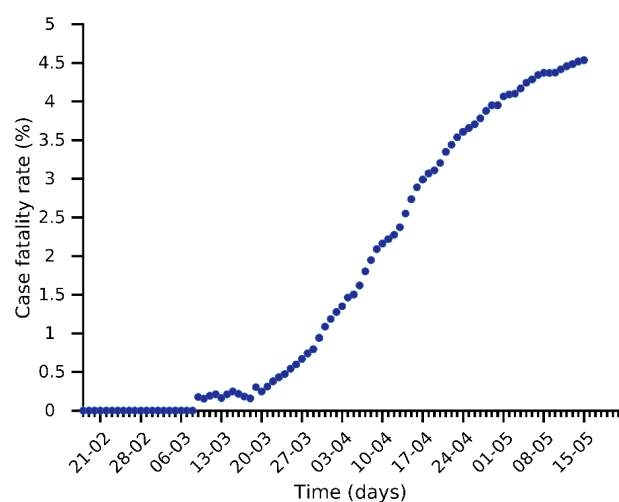
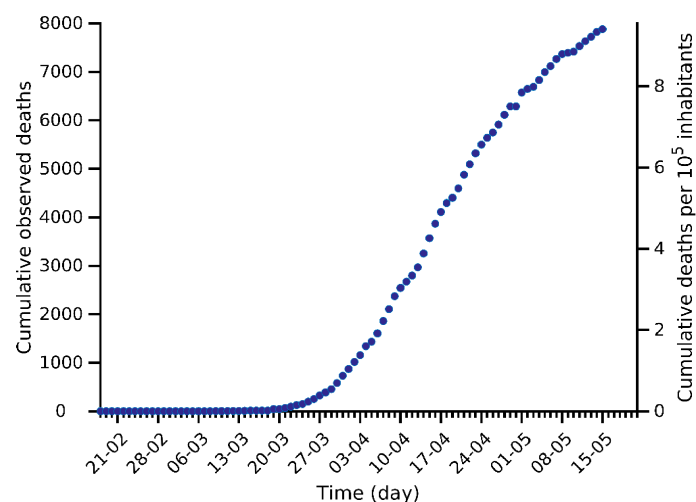
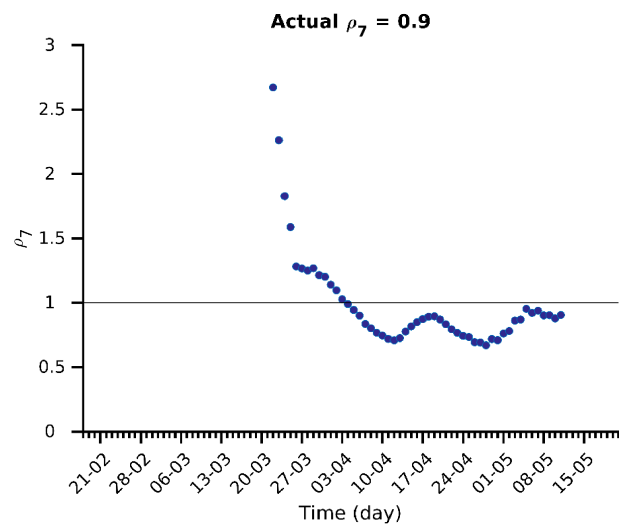
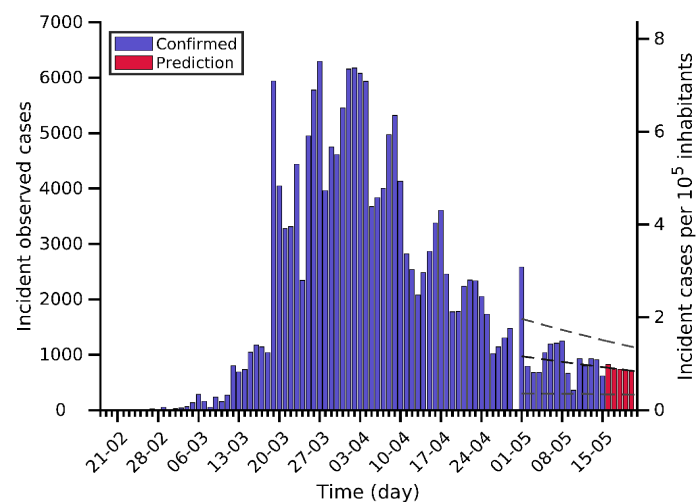
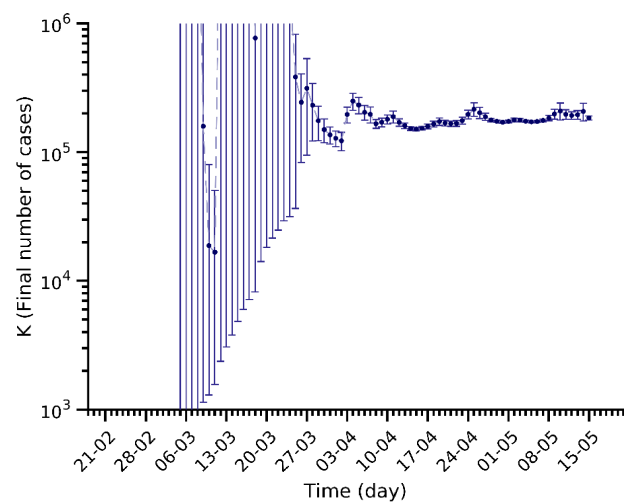
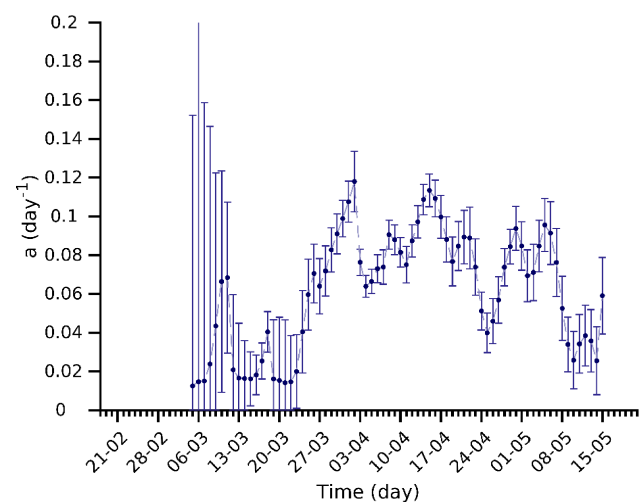
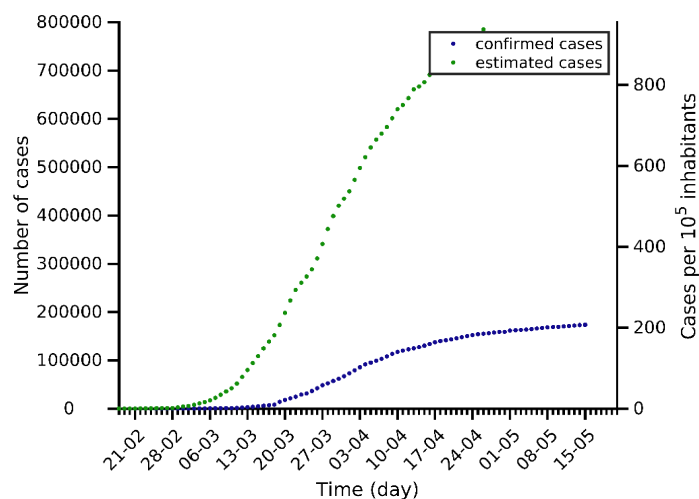
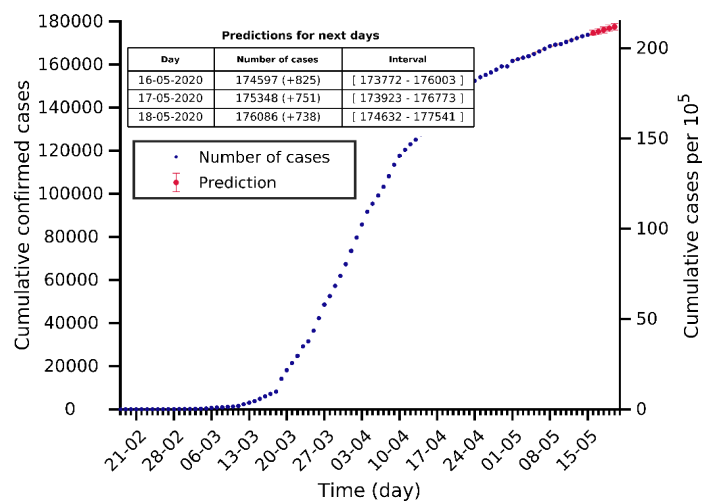
Spain 15-05-2020. Population: 47.0M. Current cumulated incidence: 489/10⁵



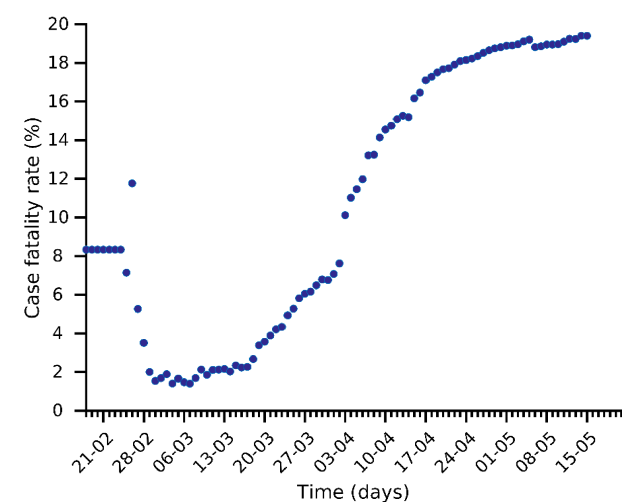
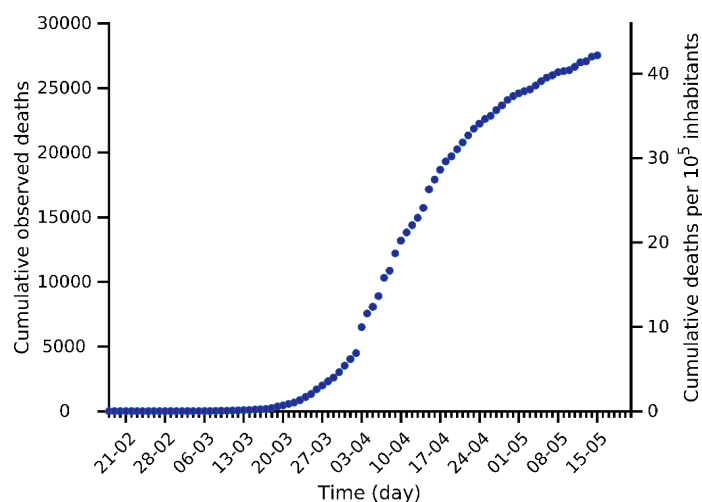
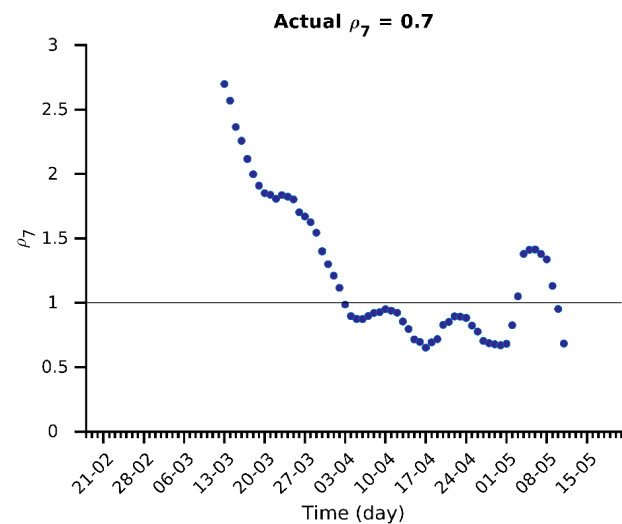
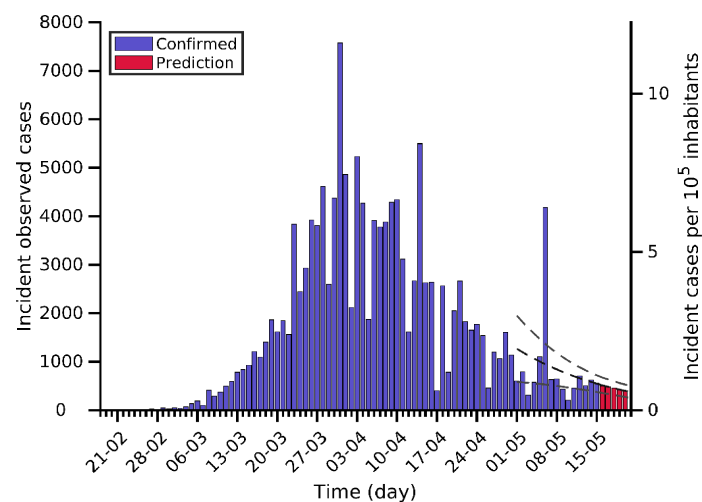
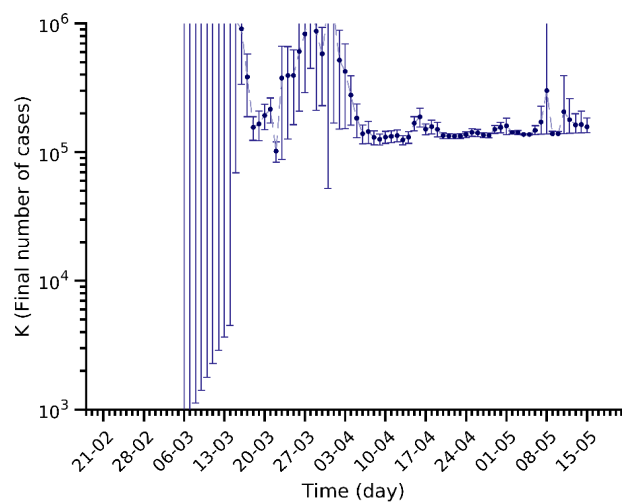
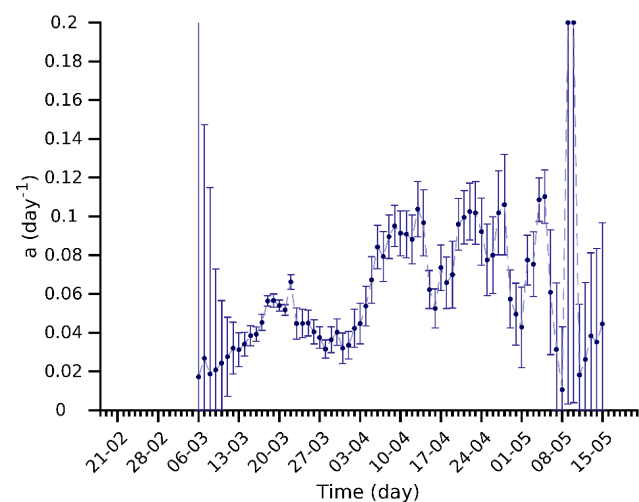
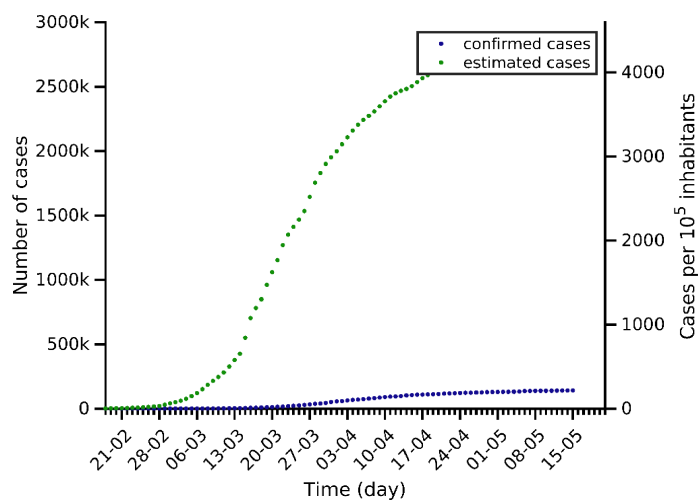
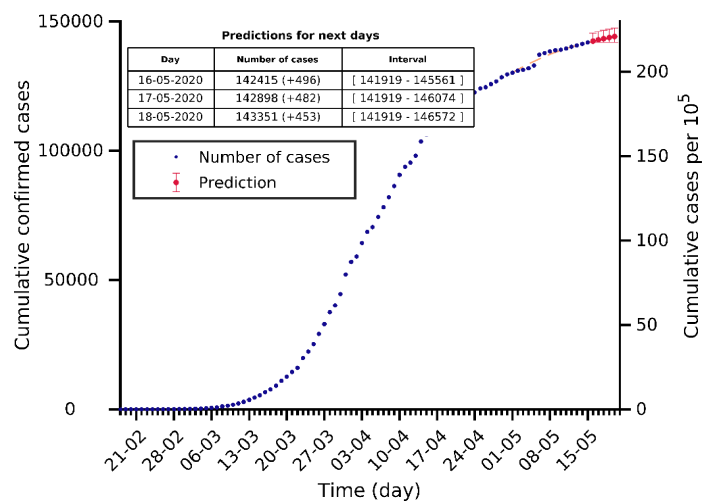
Italy 15-05-2020. Population: 60.5M. Current cumulated incidence: 370/10⁵



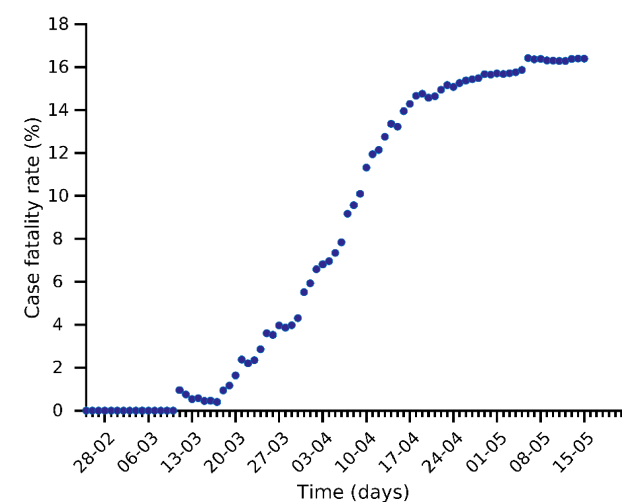
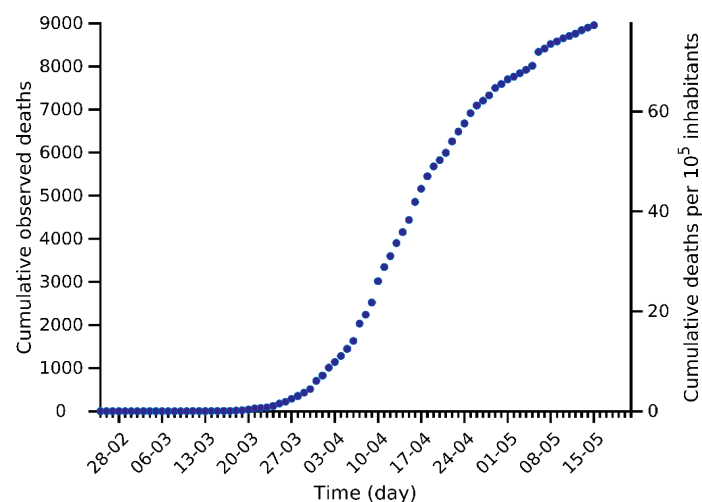
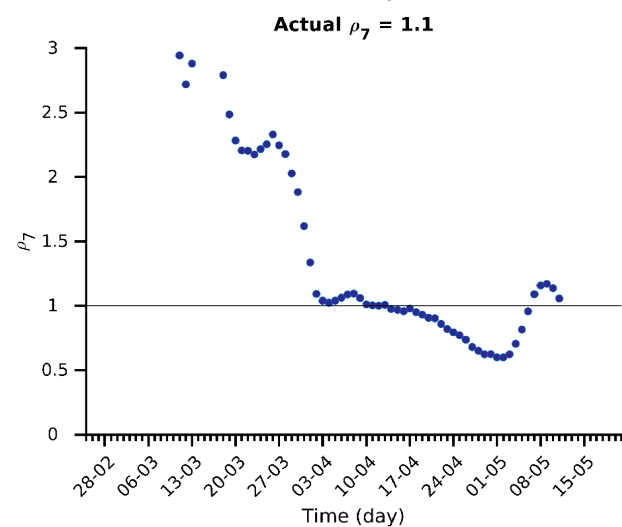
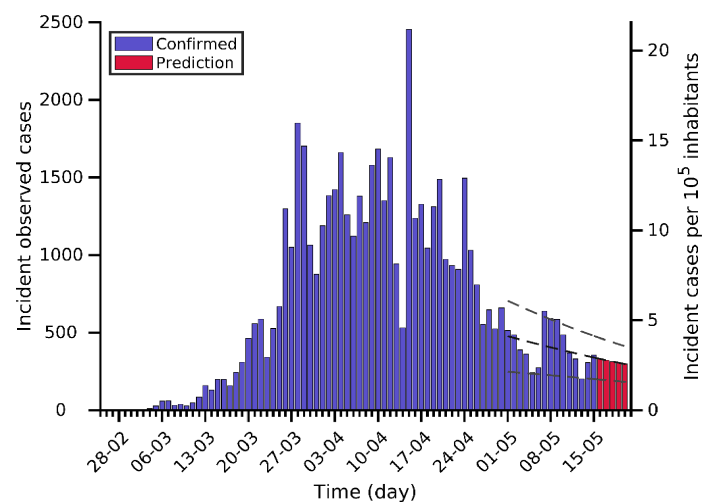
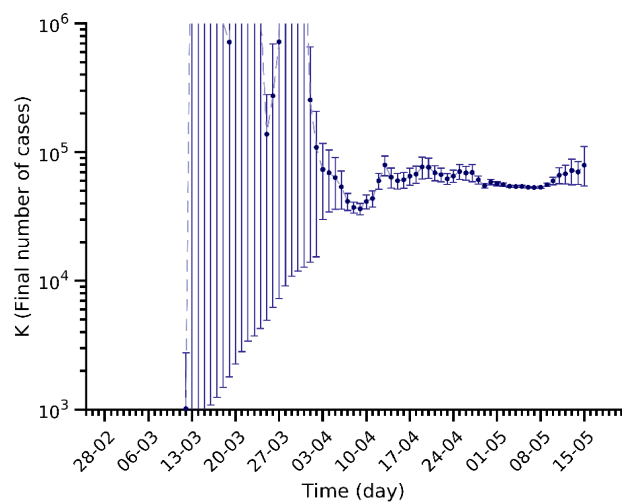
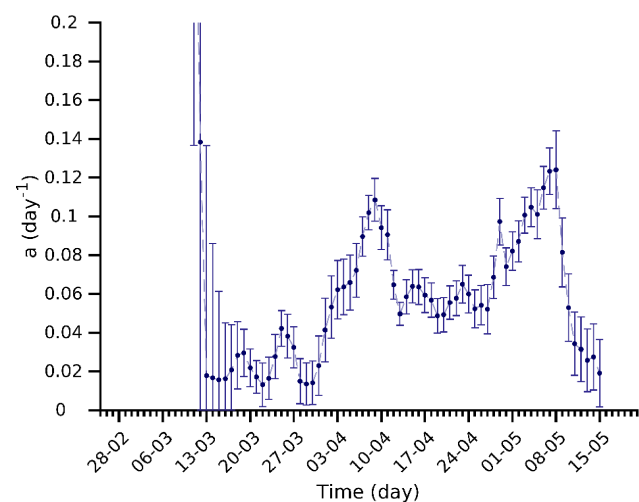
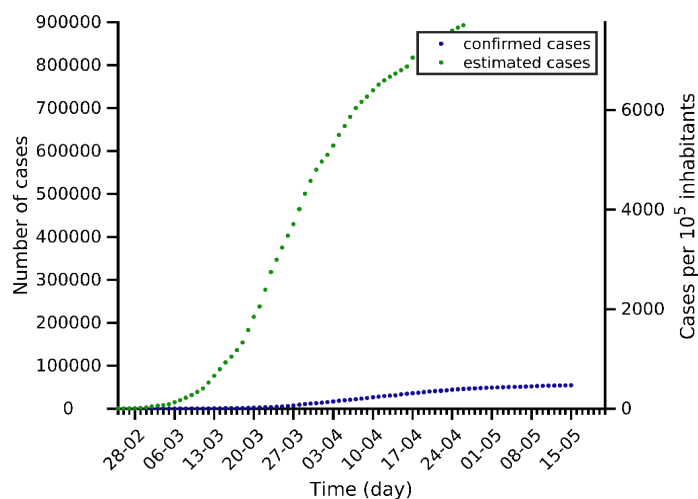
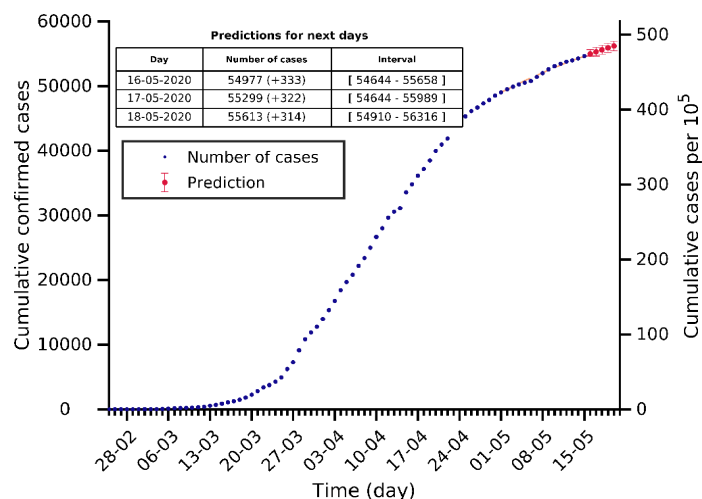
Germany 15-05-2020. Population: 83.8M. Current cumulated incidence: 207/10⁵



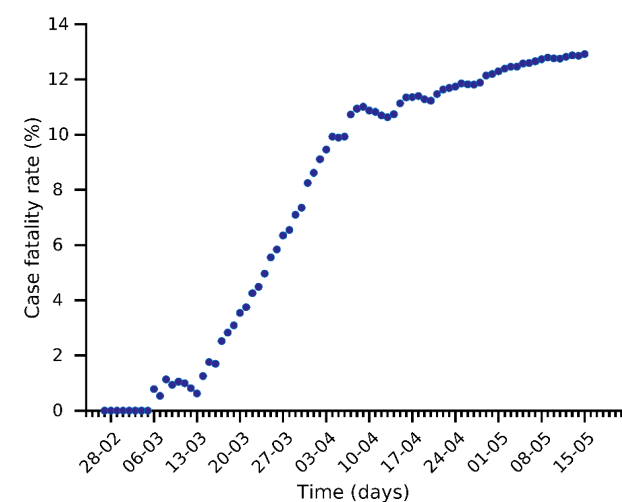
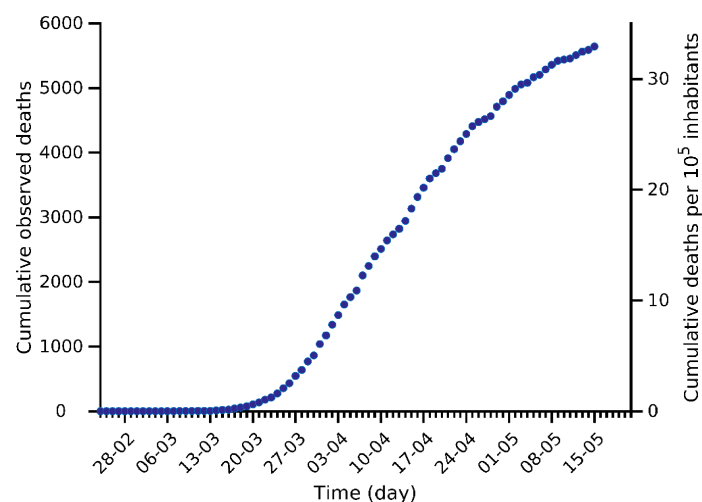
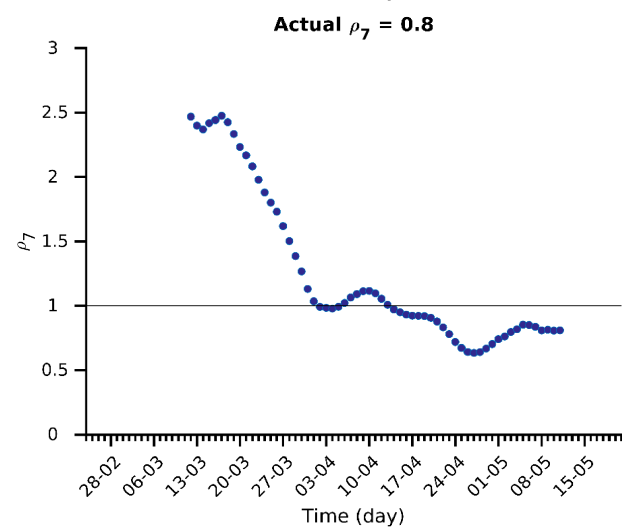
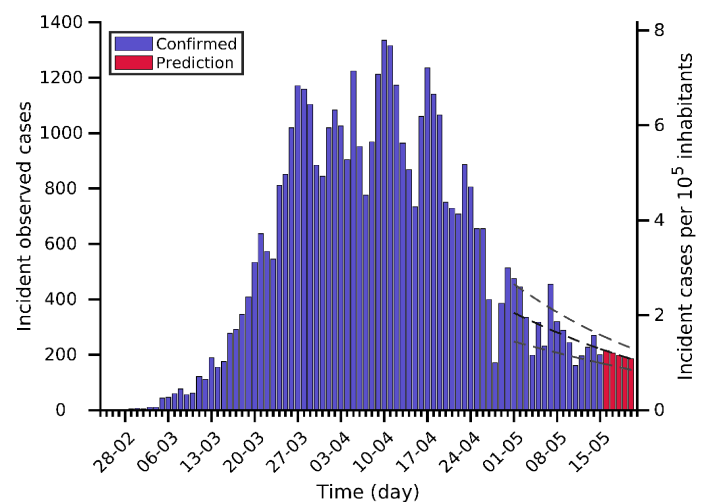
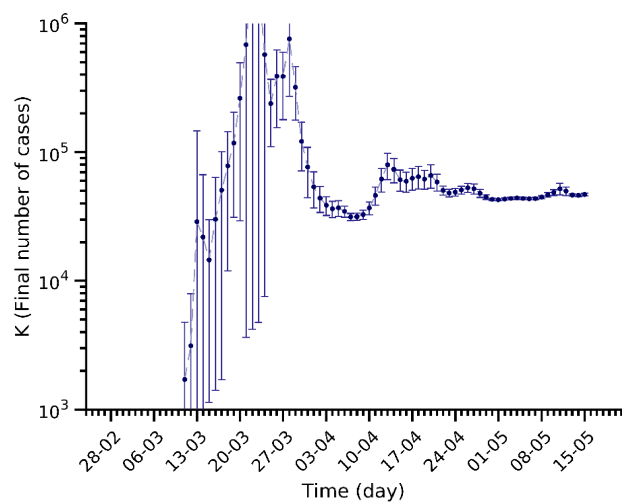
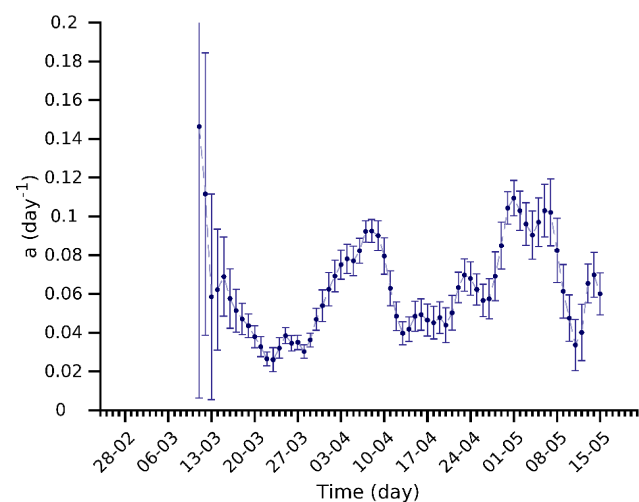
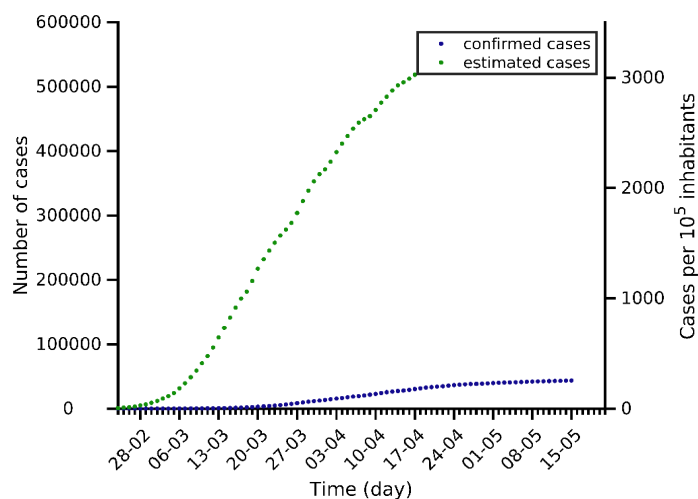
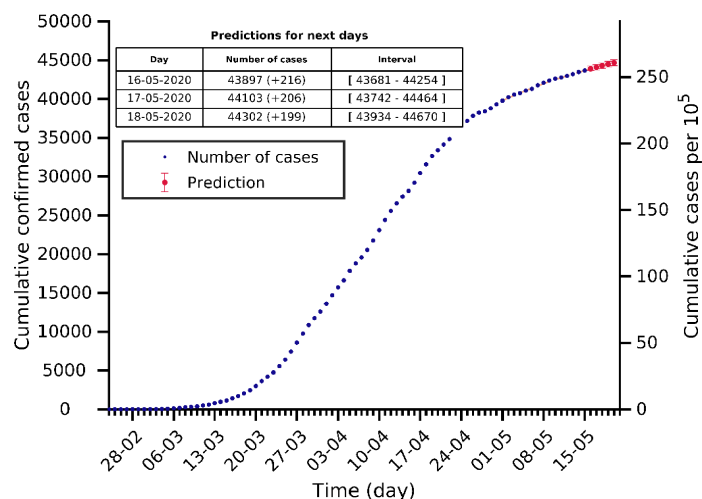
France 15-05-2020. Population: 65.3M. Current cumulated incidence: 217/10⁵



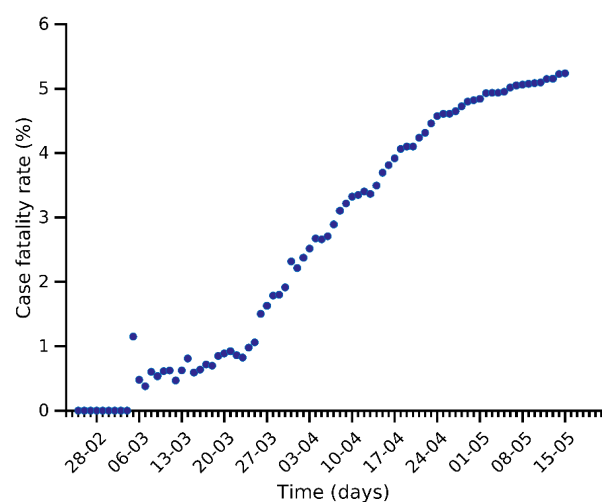
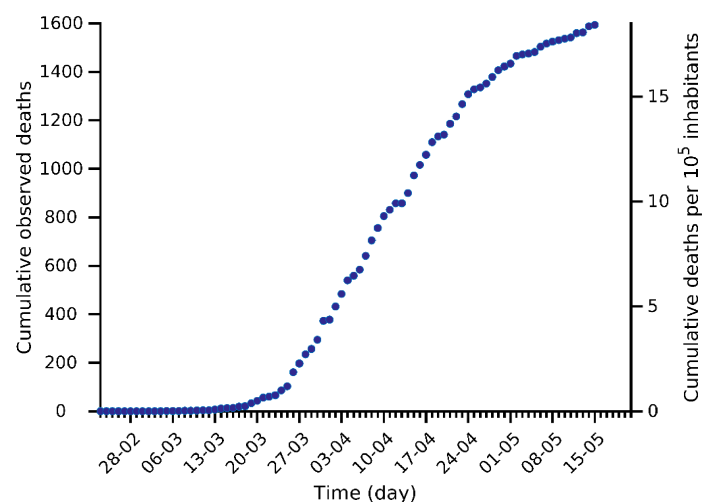
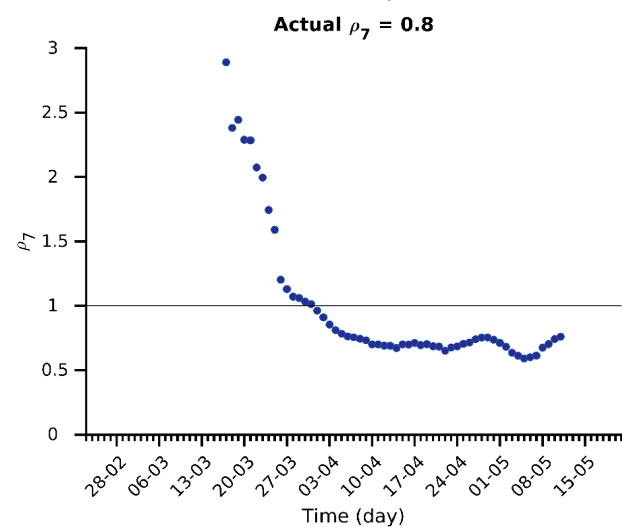
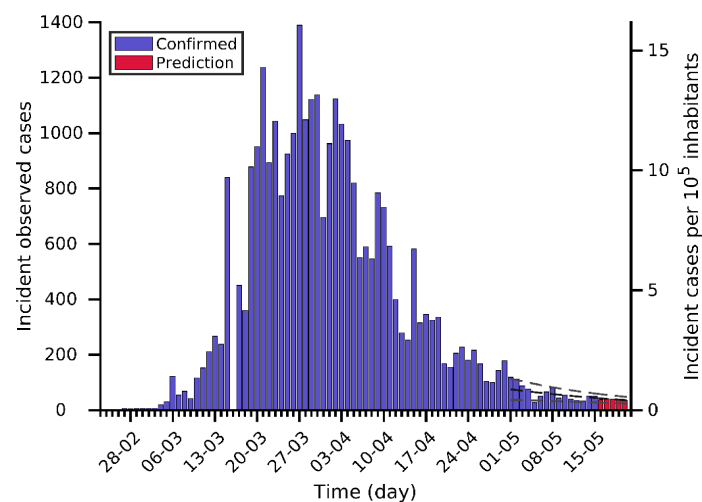
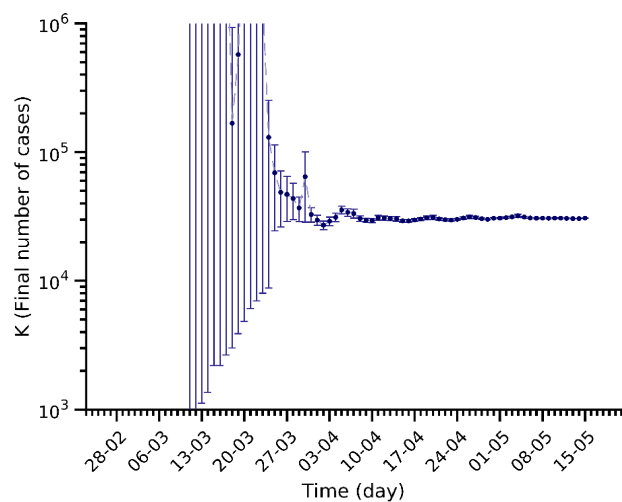
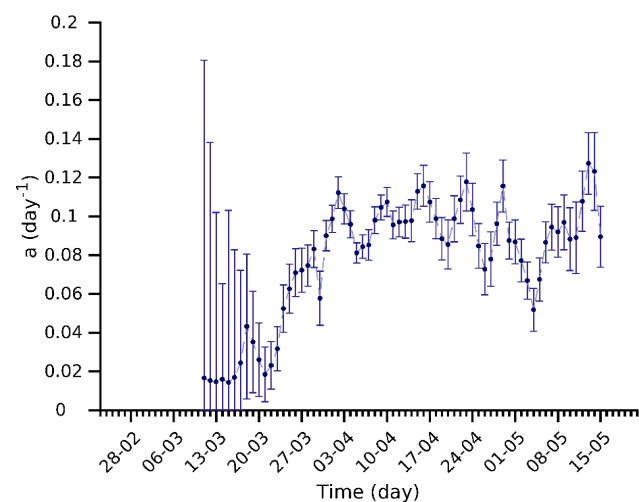
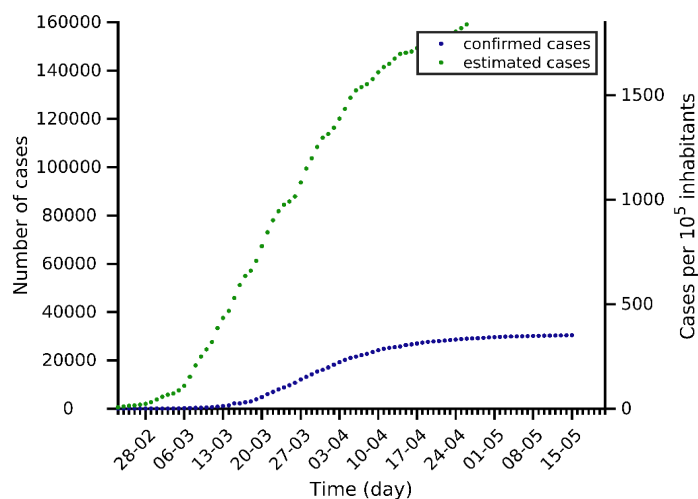
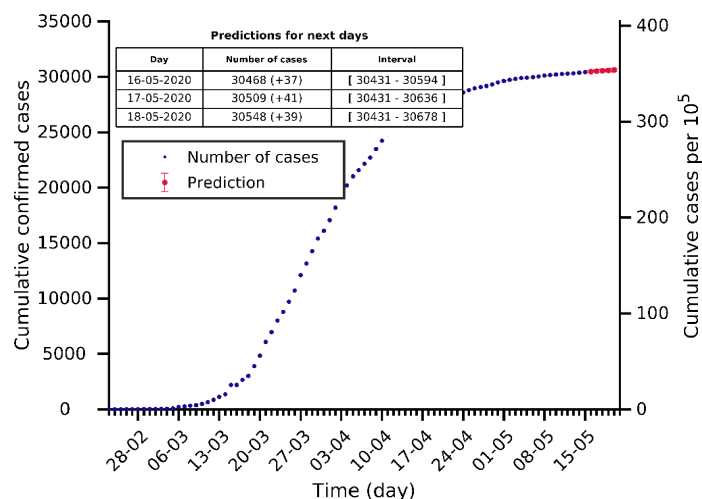
Belgium 15-05-2020. Population: 11.6M. Current cumulated incidence: 471/10⁵



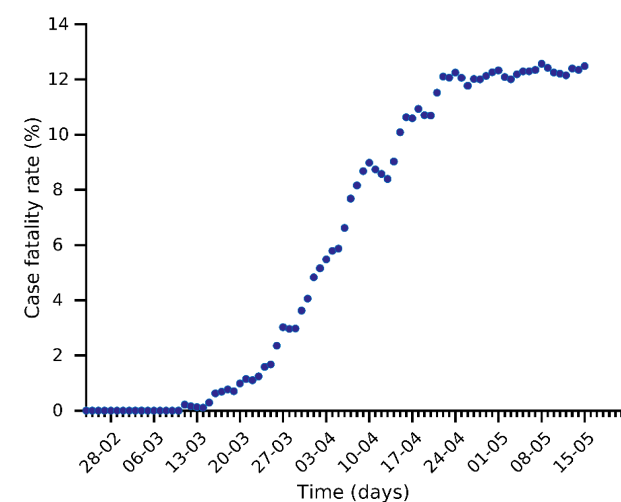
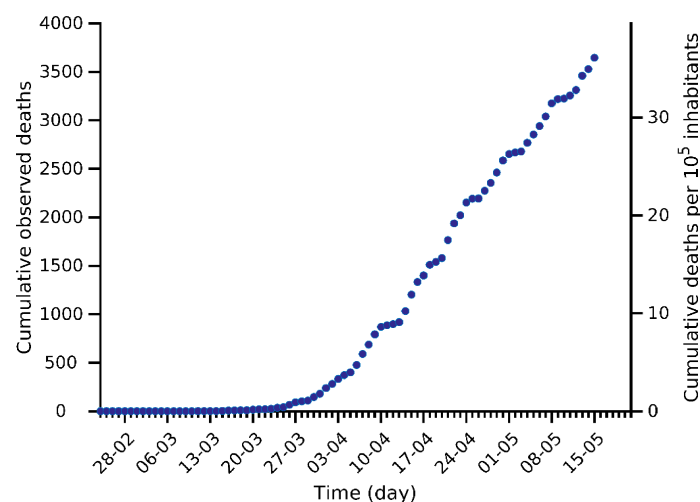
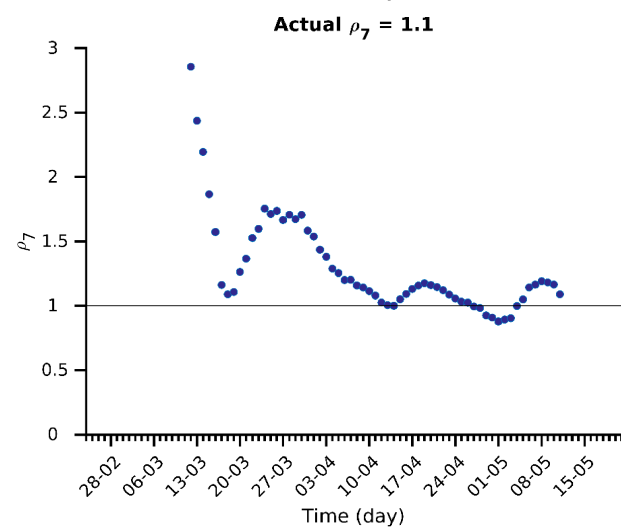
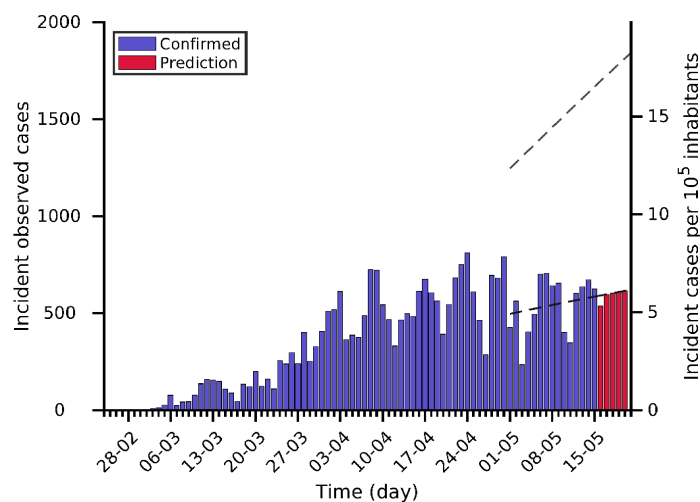
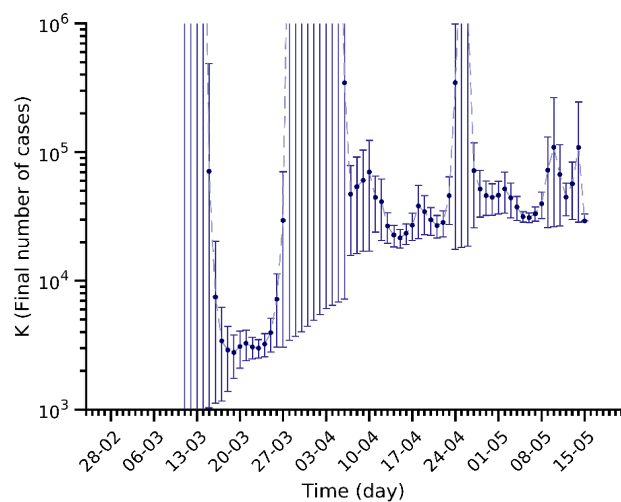
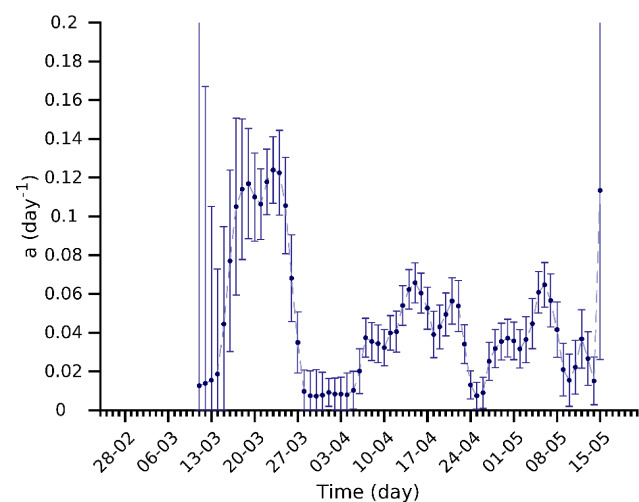
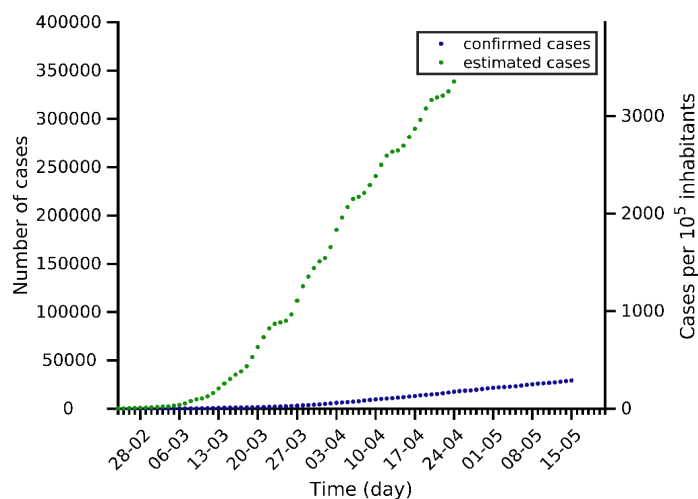
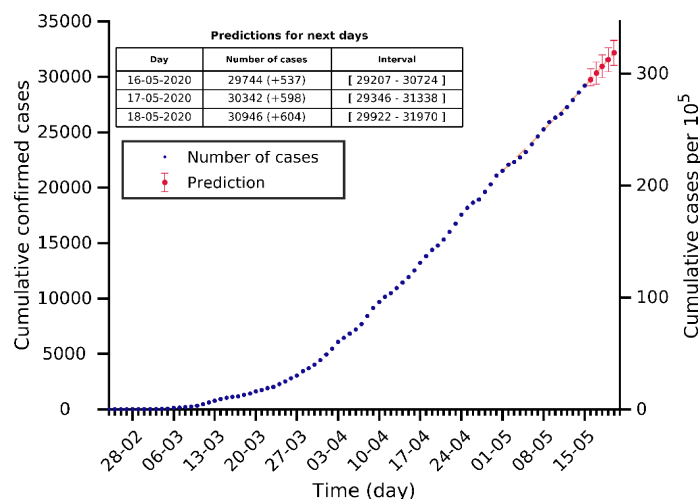
Netherlands 15-05-2020. Population: 17.1M. Current cumulated incidence: 255/10⁵



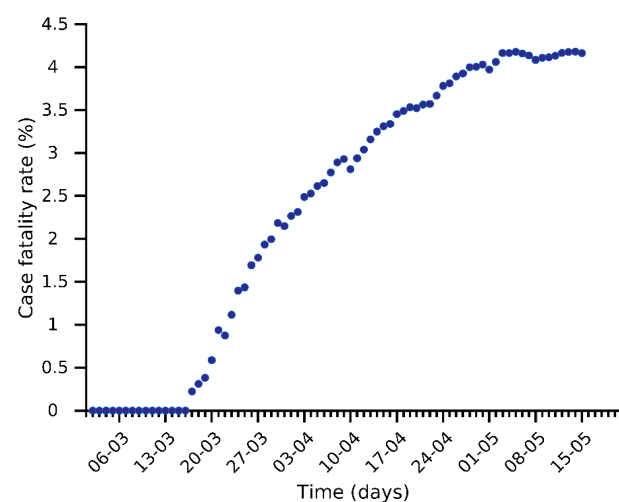
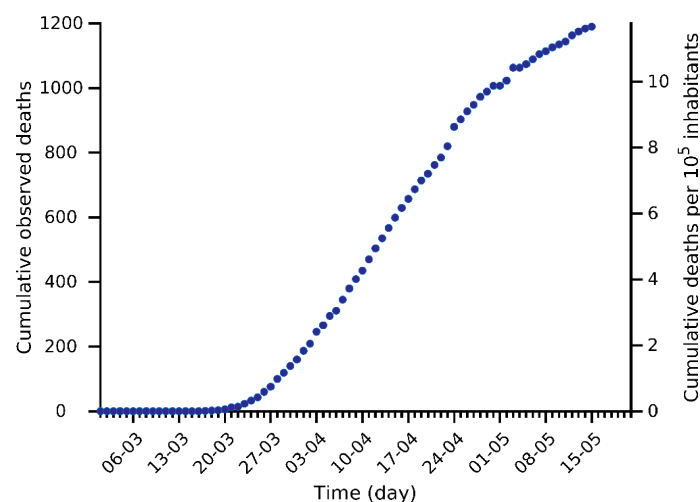
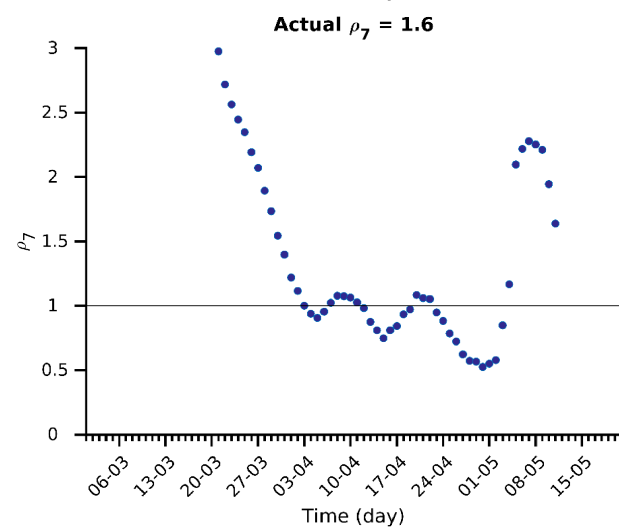
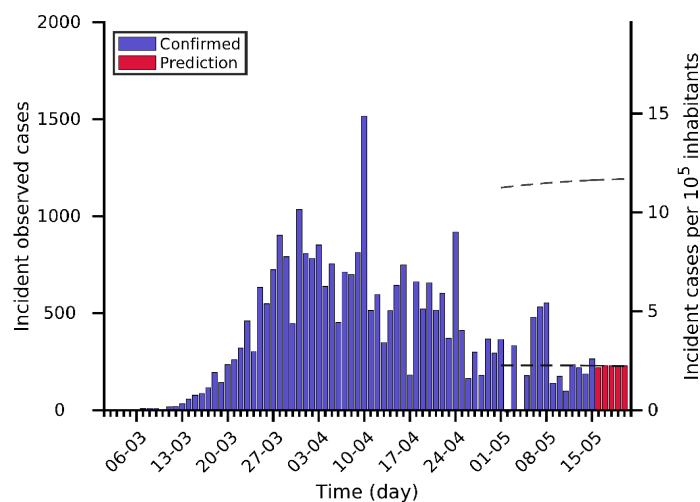
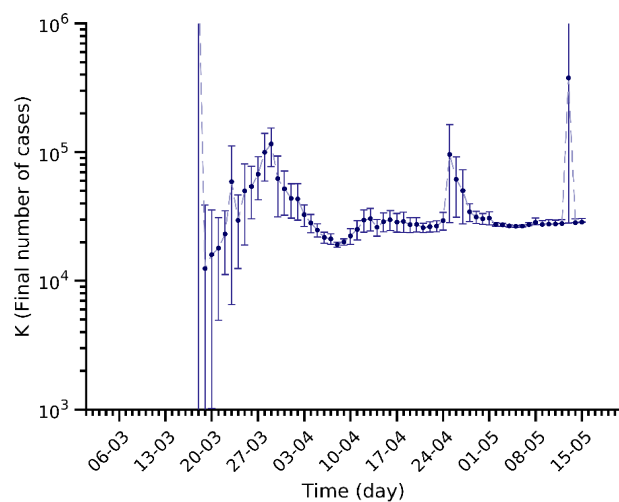
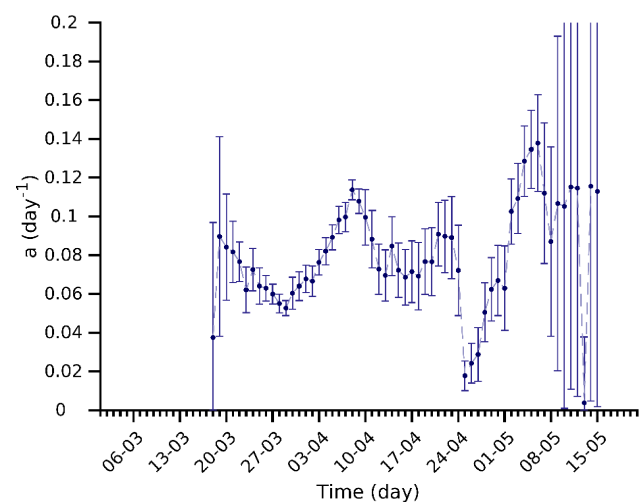
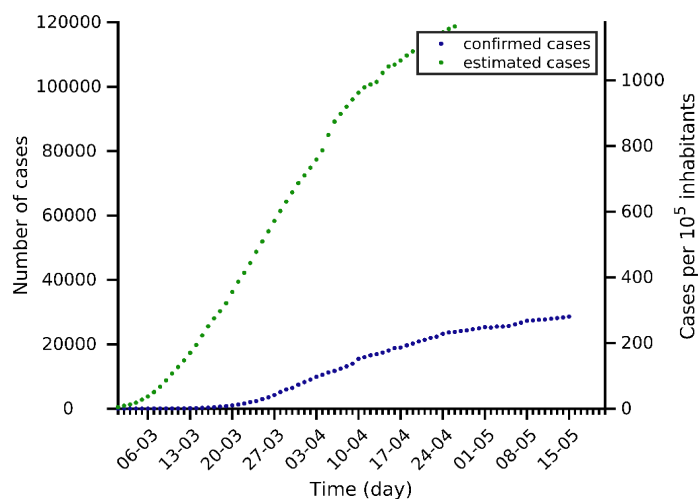
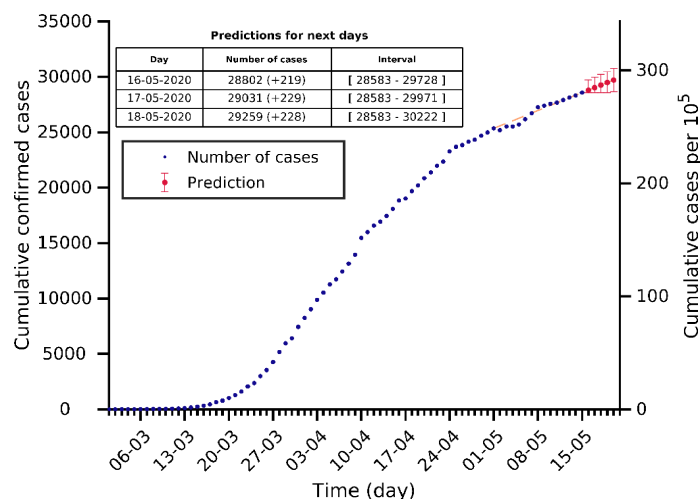
Switzerland 15-05-2020. Population: 8.7M. Current cumulated incidence: 352/10⁵



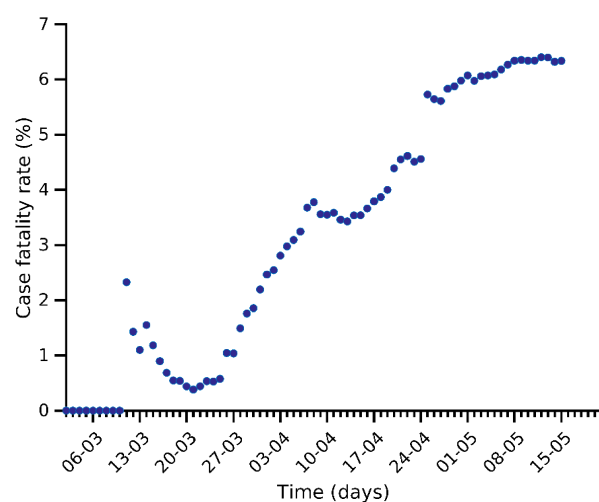
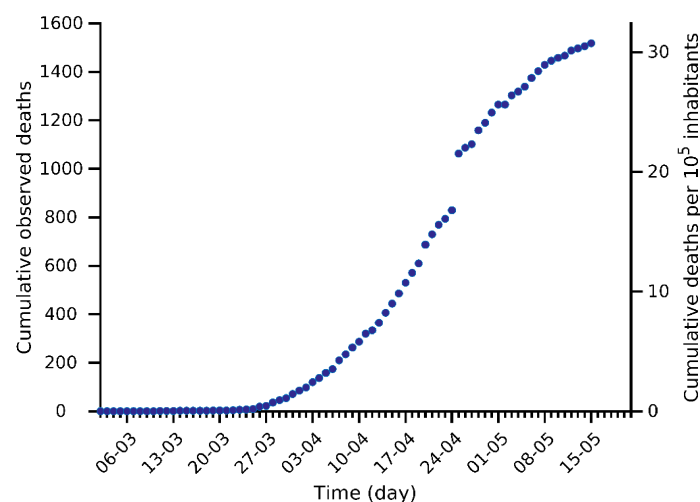
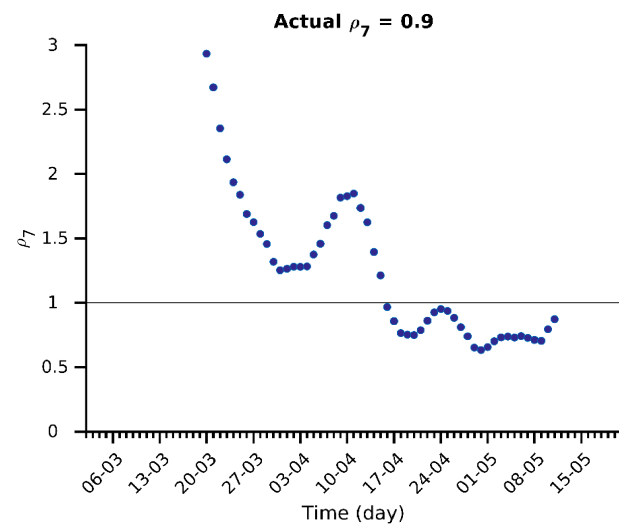
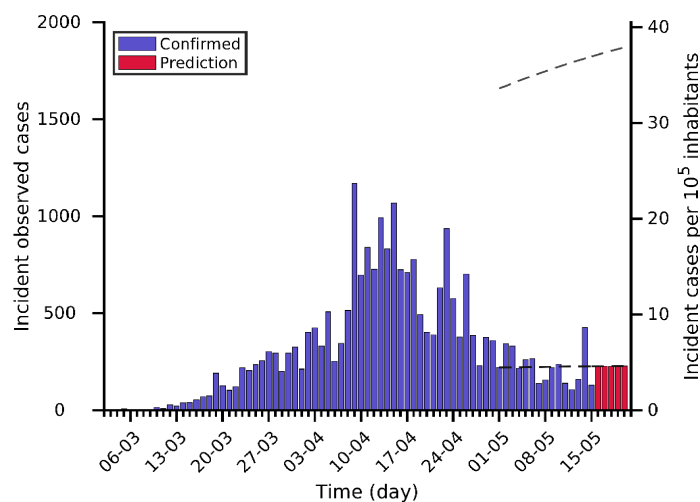
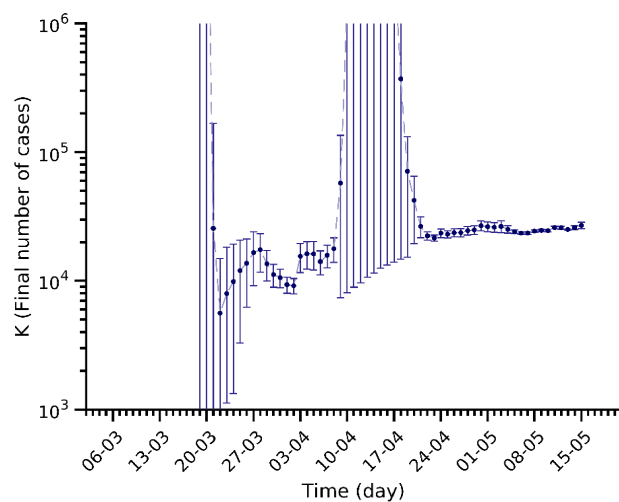
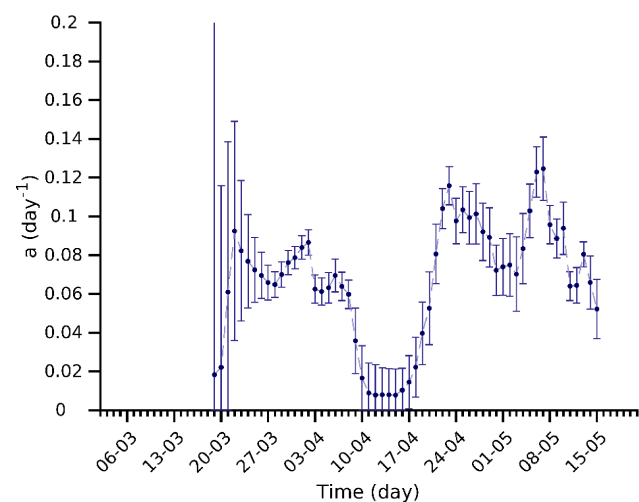
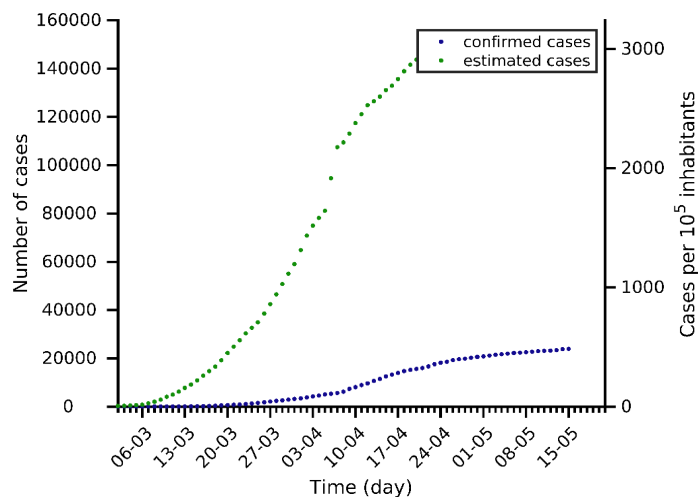
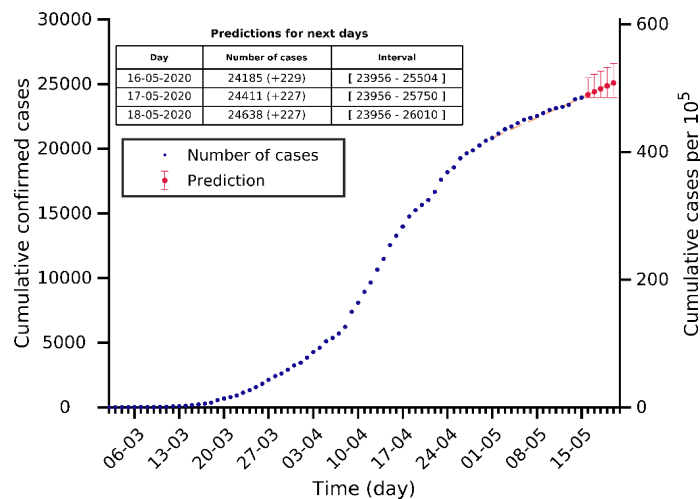
Sweden 15-05-2020. Population: 10.1M. Current cumulated incidence: 289/10⁵



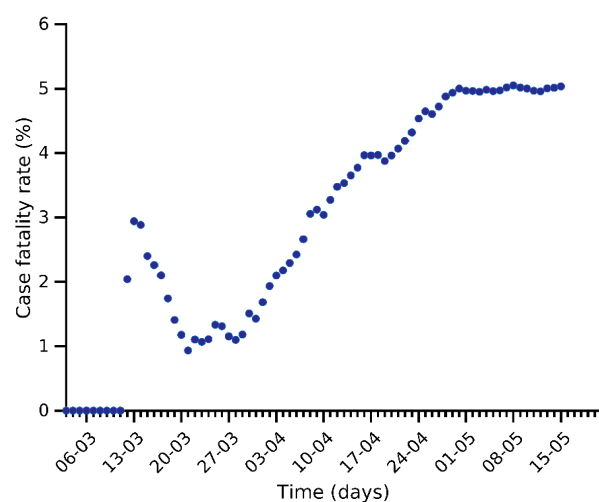
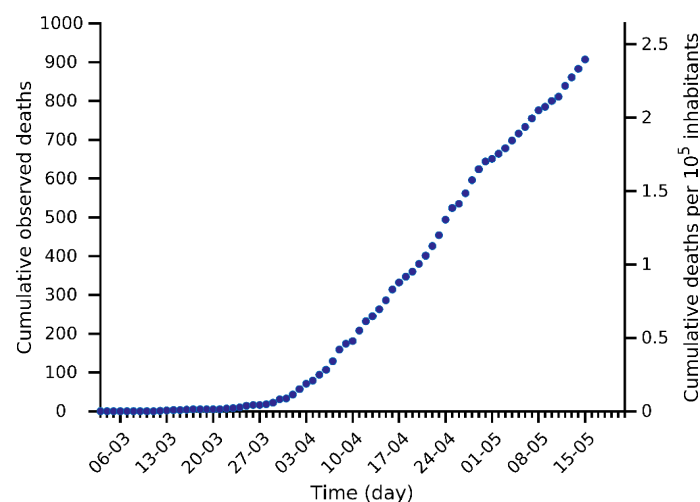
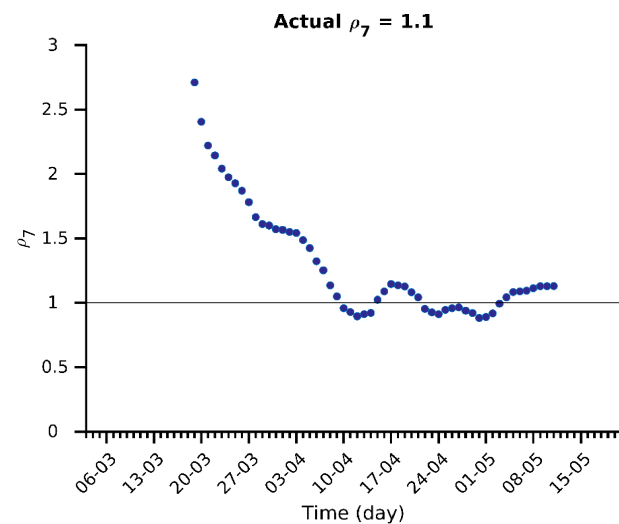
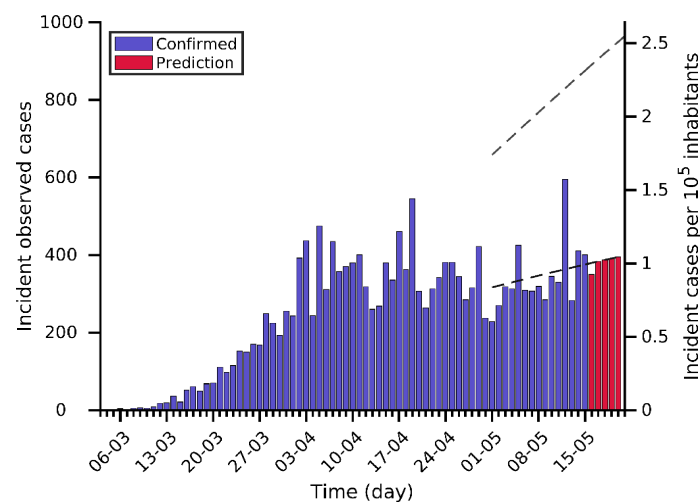
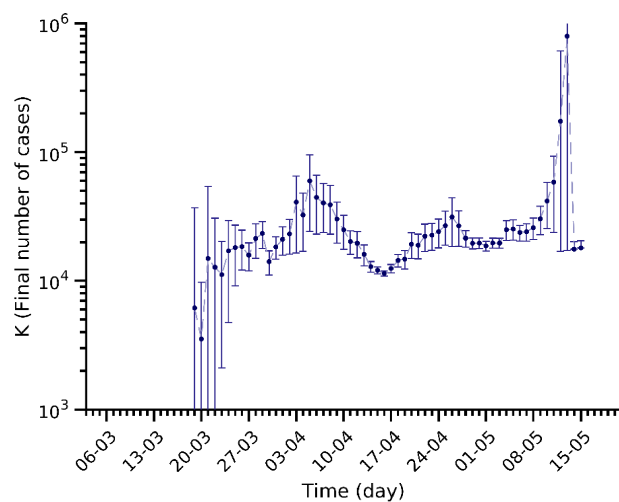
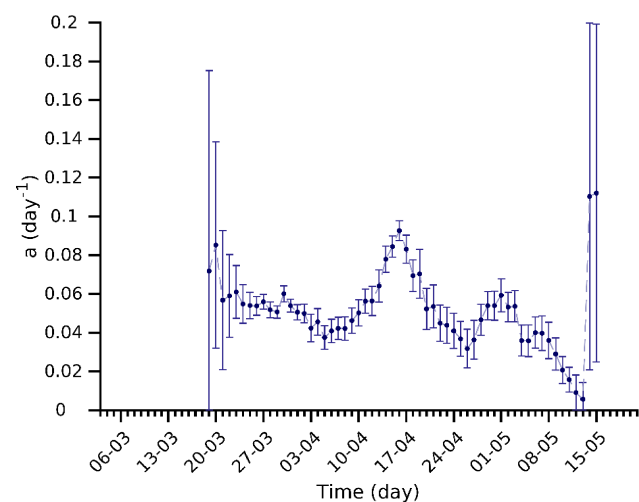
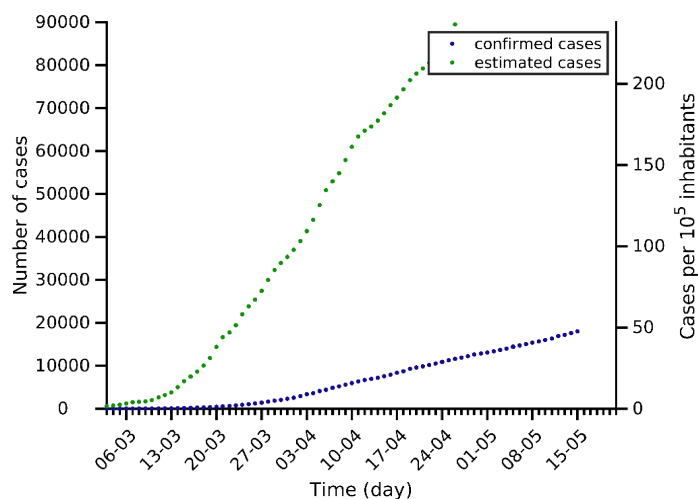
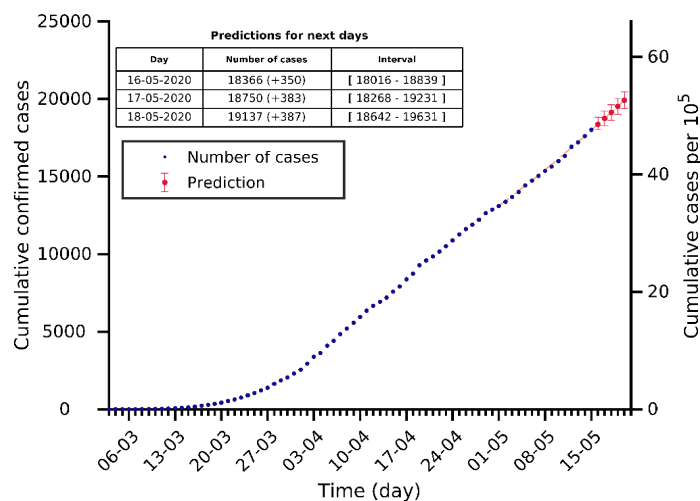
Portugal 15-05-2020. Population: 10.2M. Current cumulated incidence: 280/10⁵



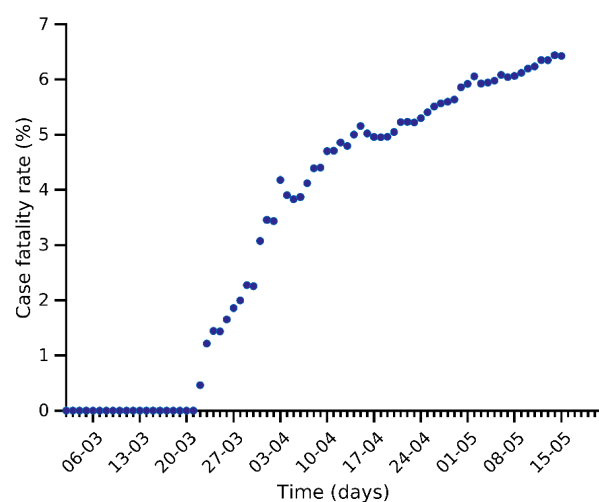
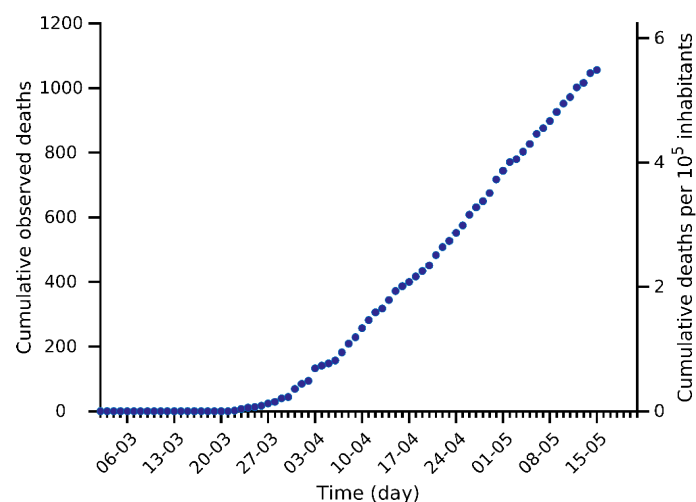
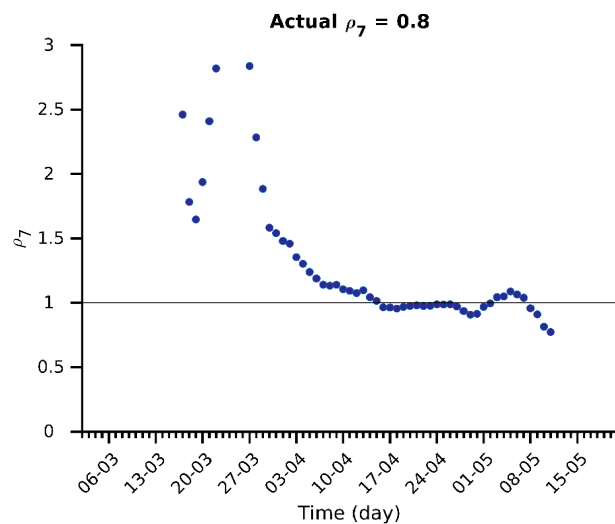
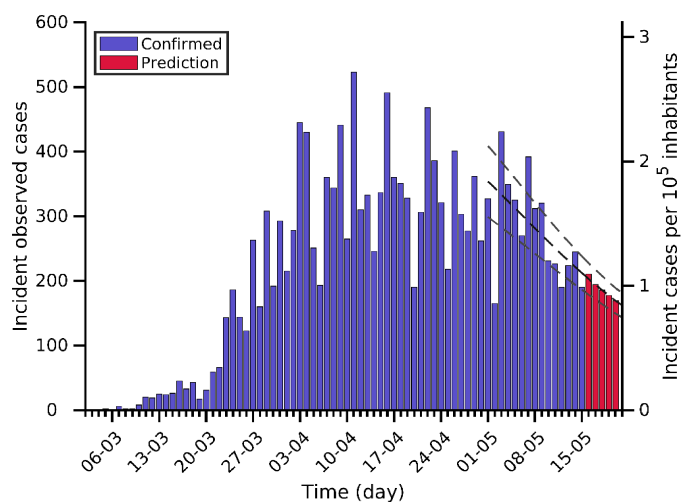
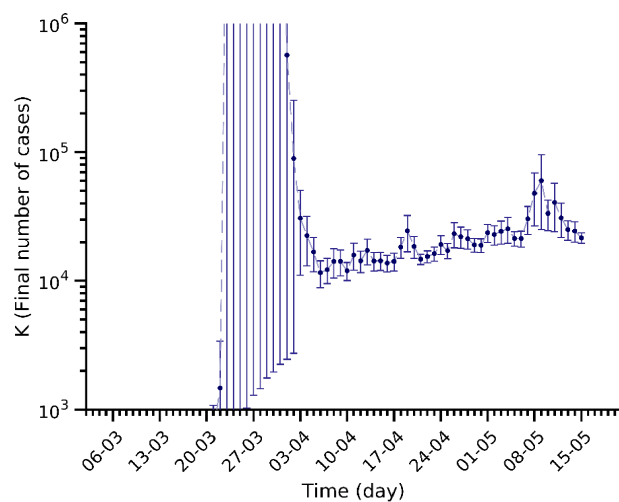
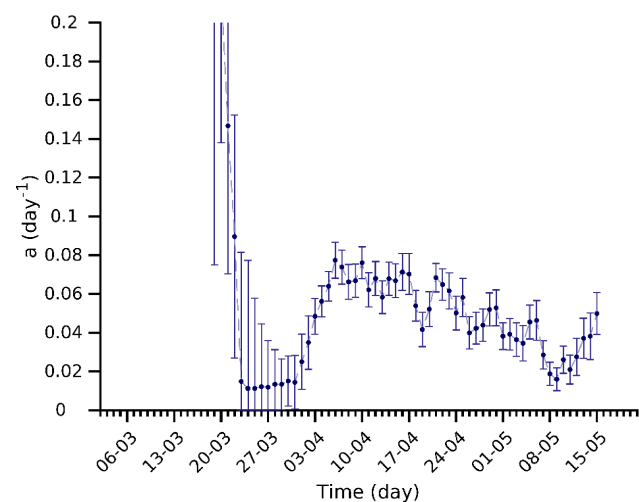
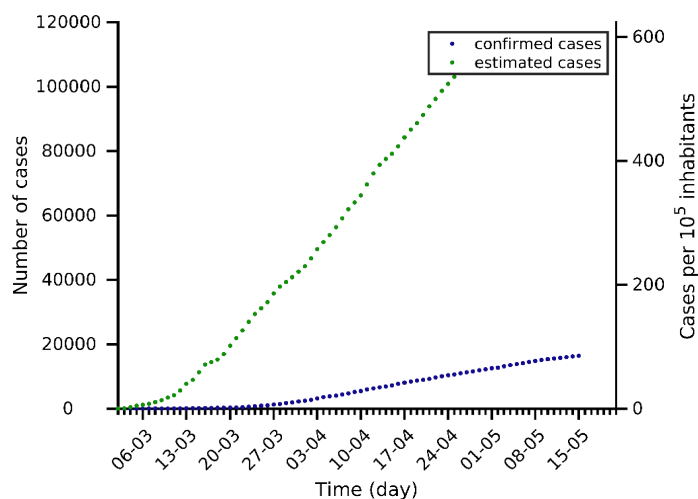
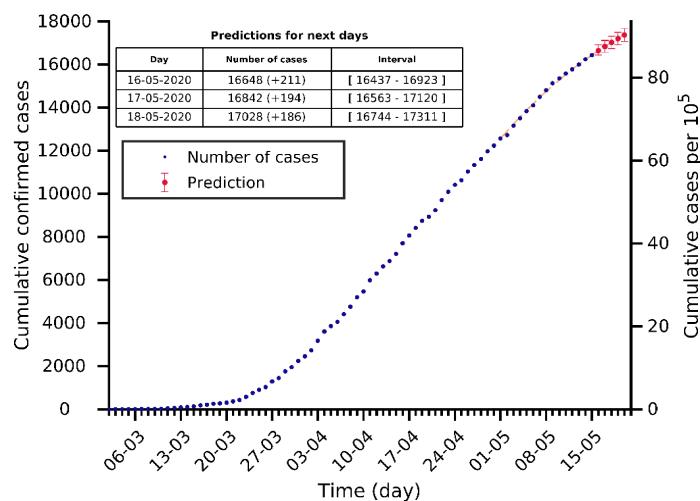
Ireland 15-05-2020. Population: 4.9M. Current cumulated incidence: 485/10⁵



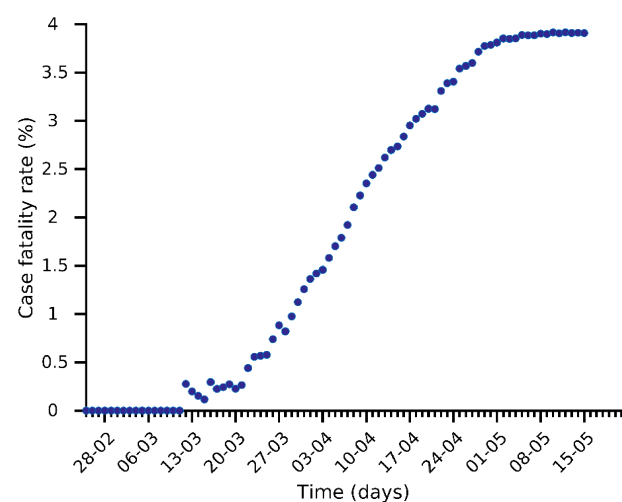
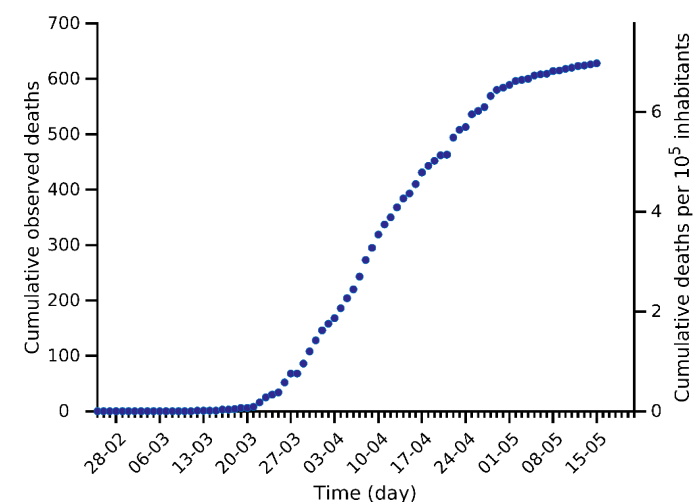
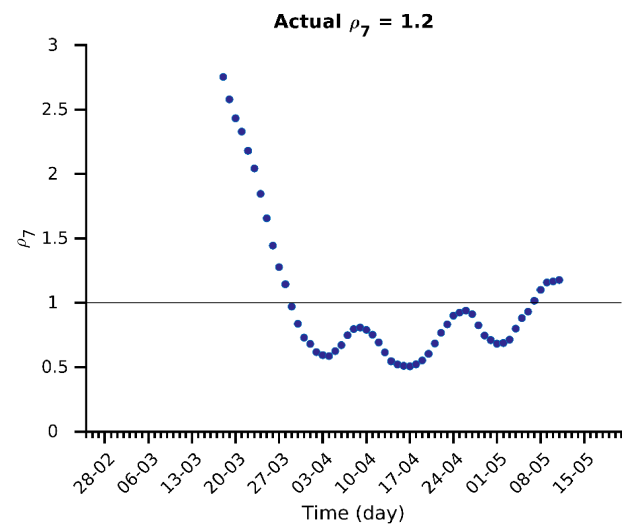
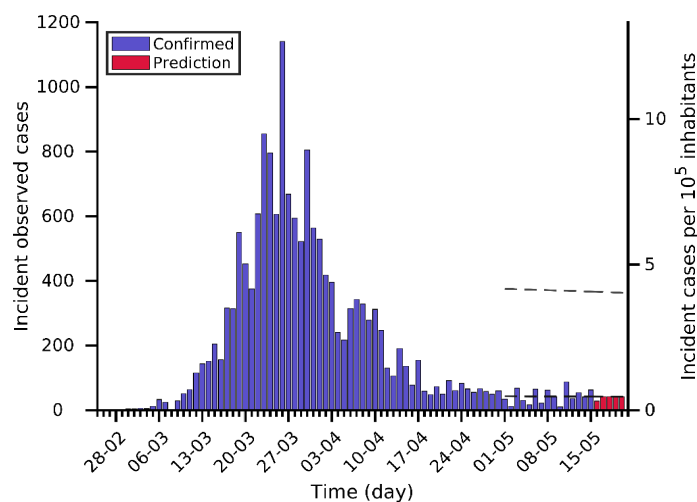
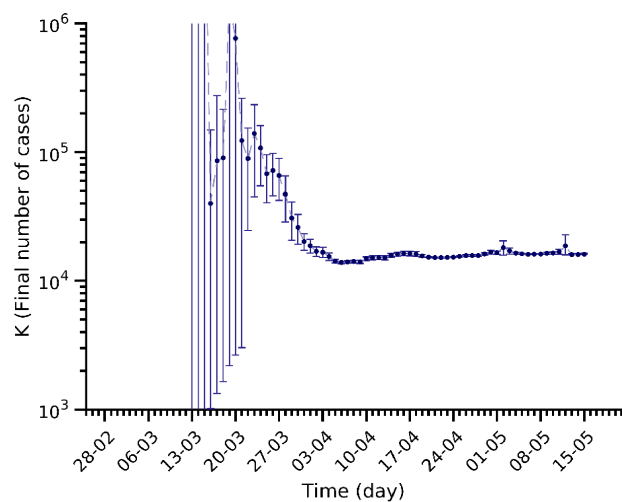
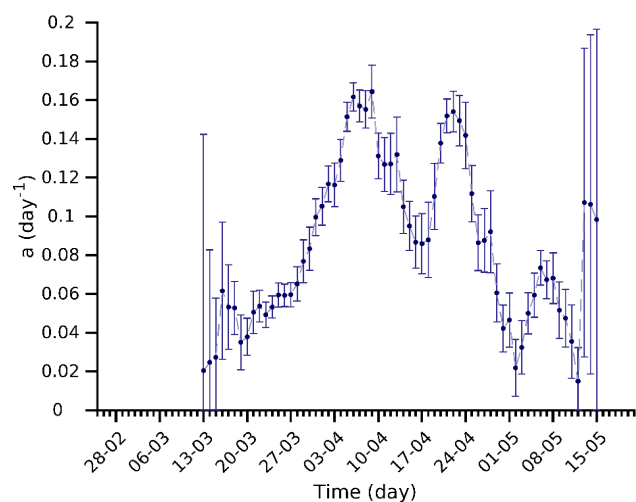
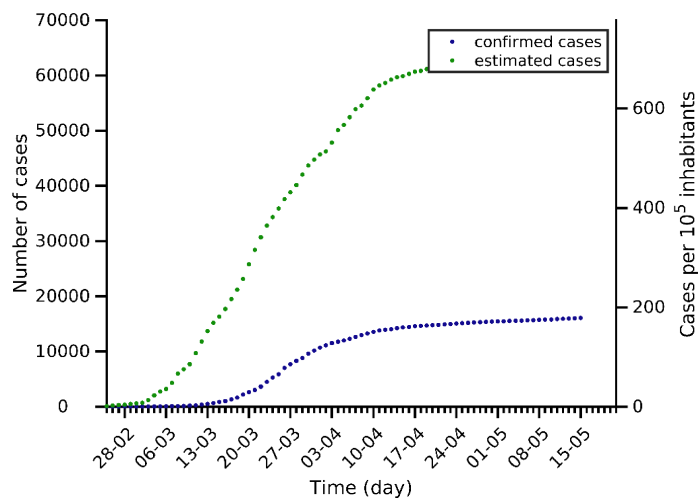
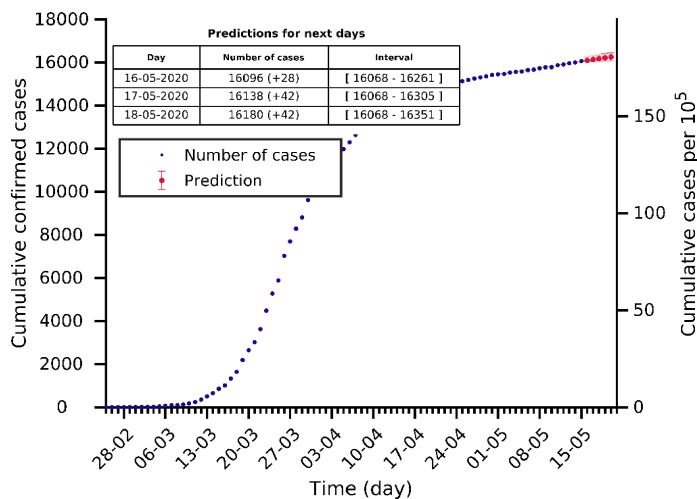
Poland 15-05-2020. Population: 37.8M. Current cumulated incidence: 48/10⁵



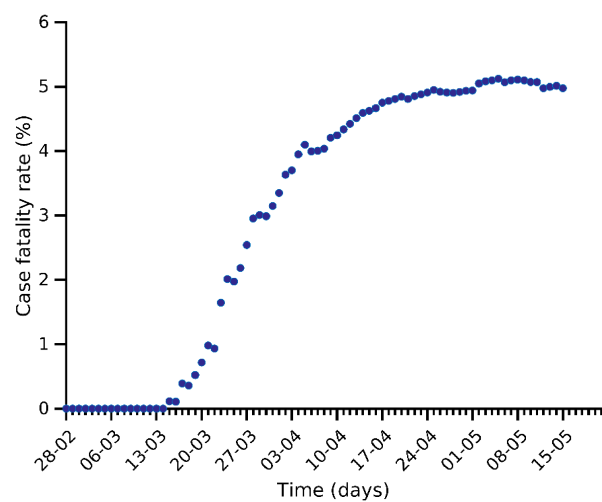
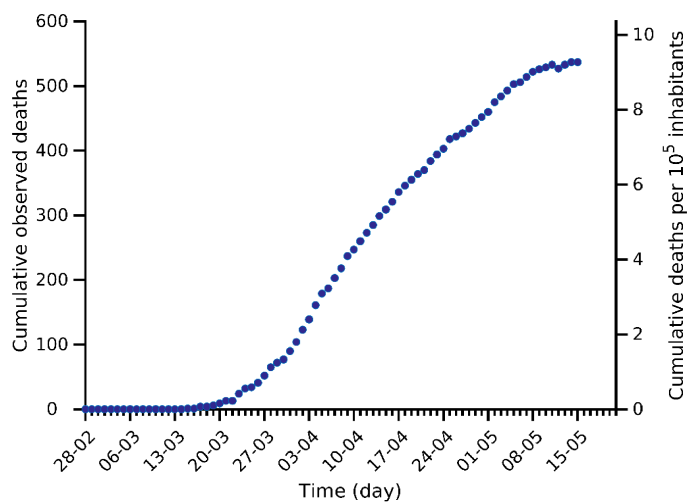
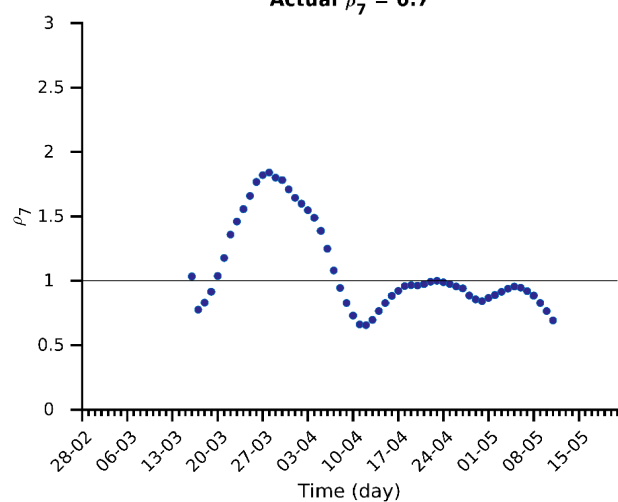
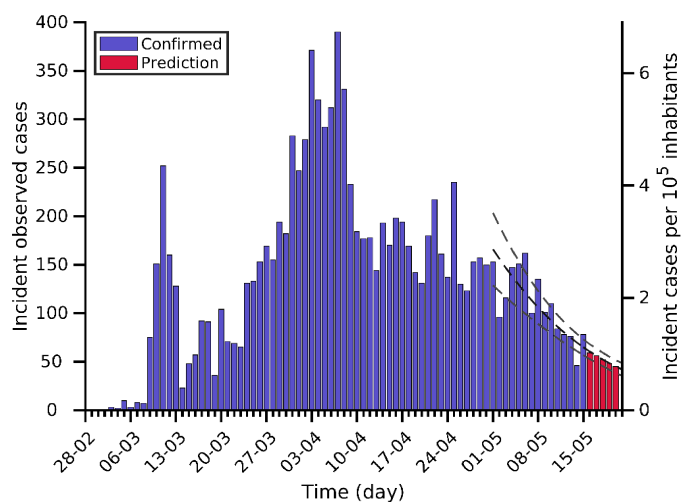
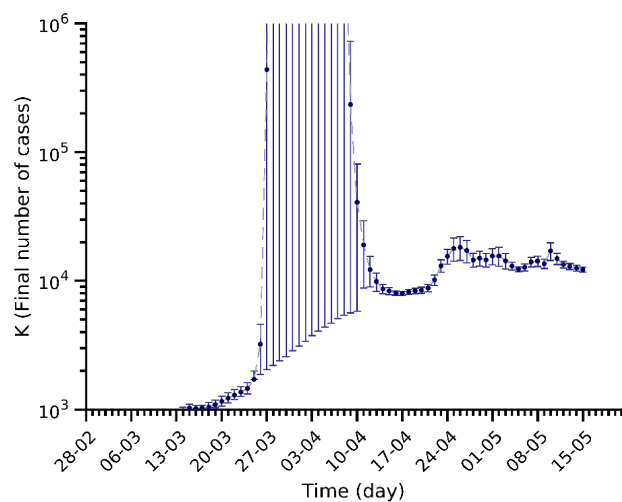
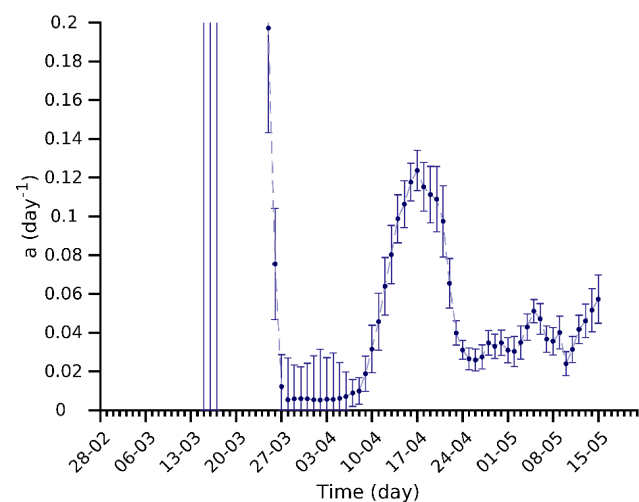
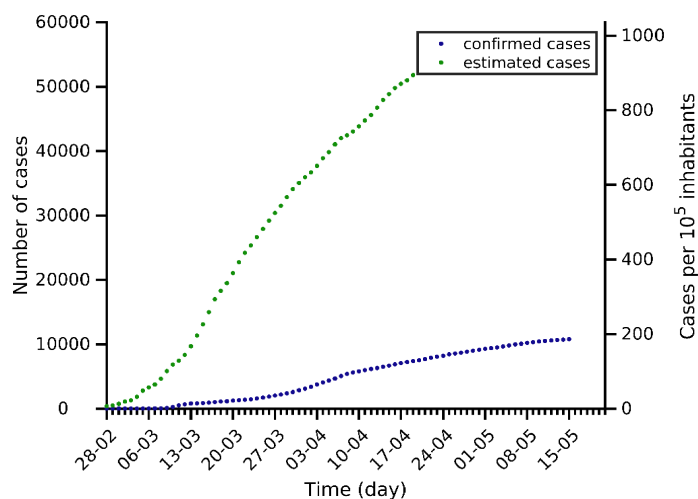
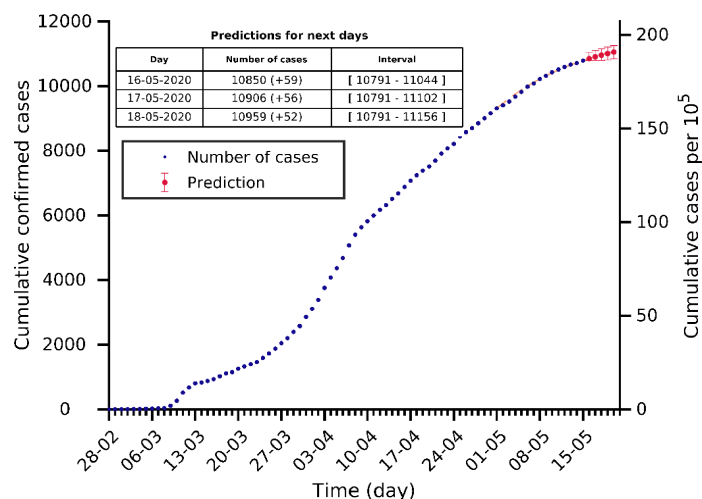
Romania 15-05-2020. Population: 19.2M. Current cumulated incidence: 85/10⁵



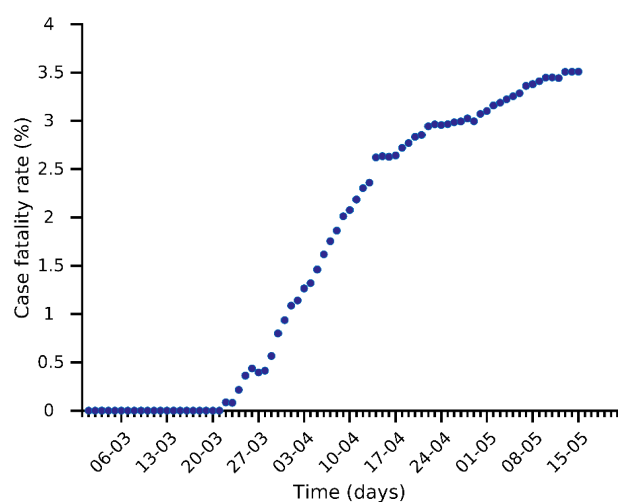
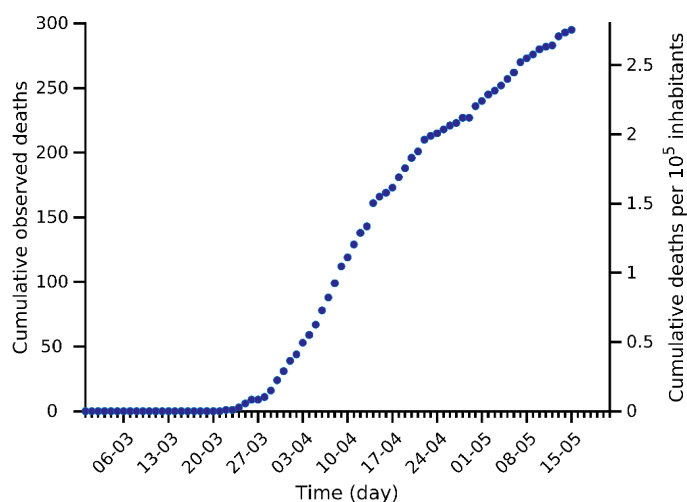
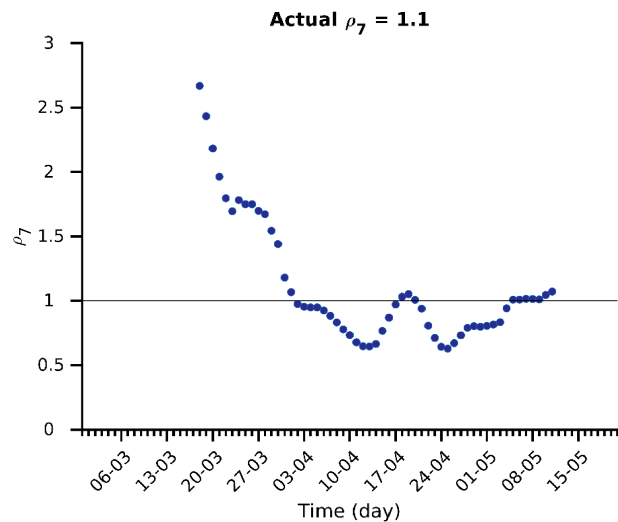
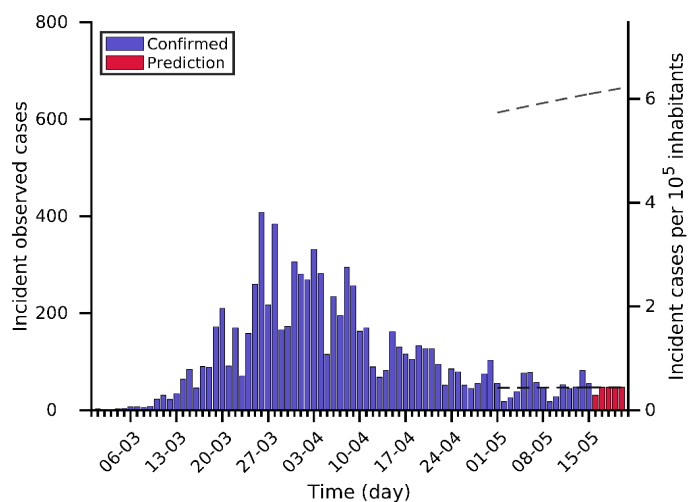
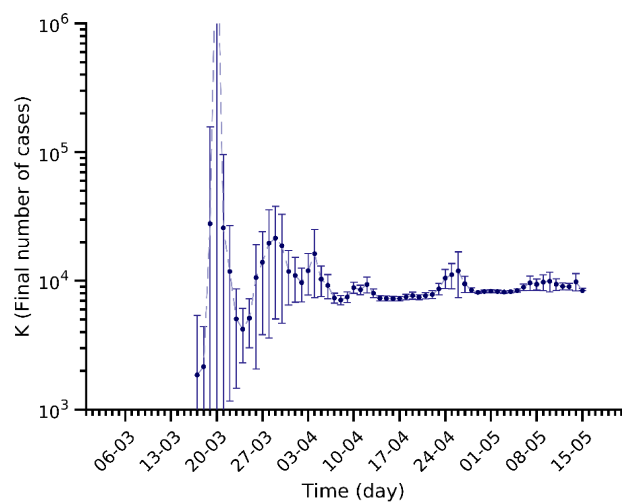
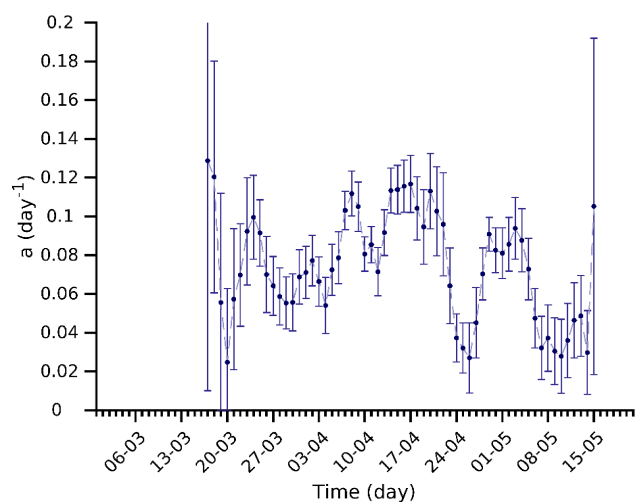
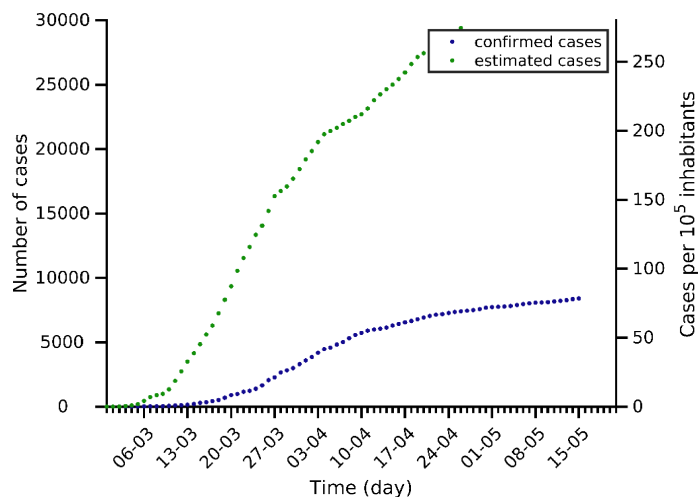
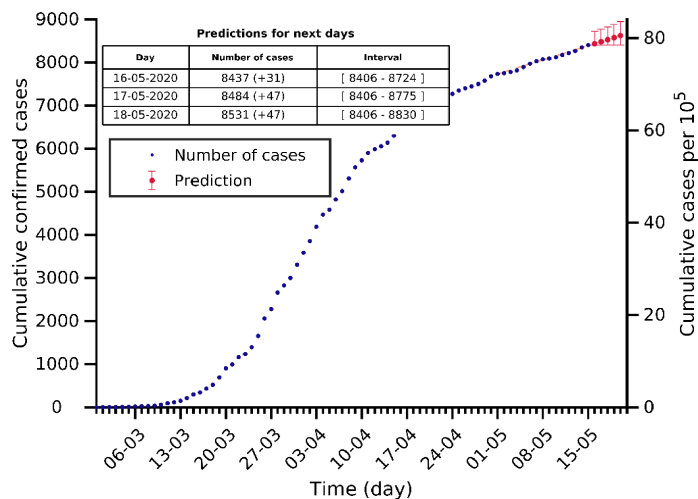
Austria 15-05-2020. Population: 9.0M. Current cumulated incidence: 178/10⁵



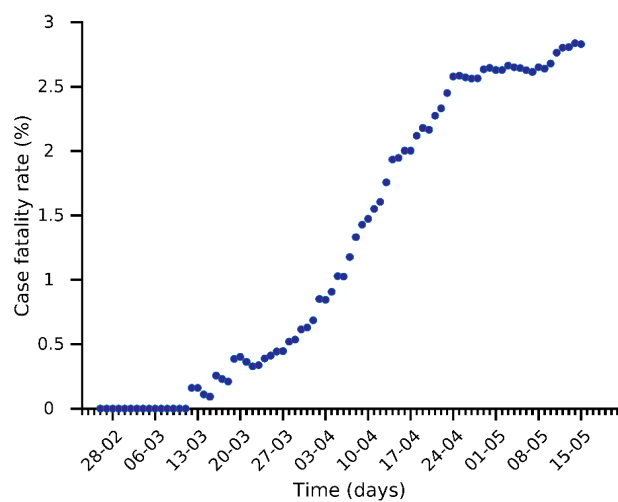
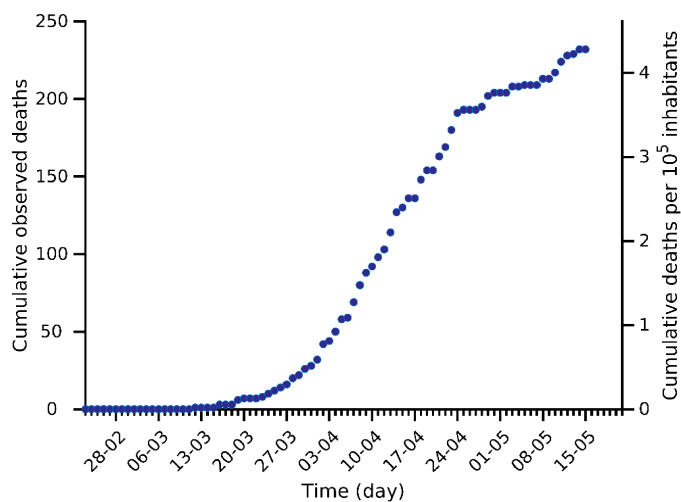
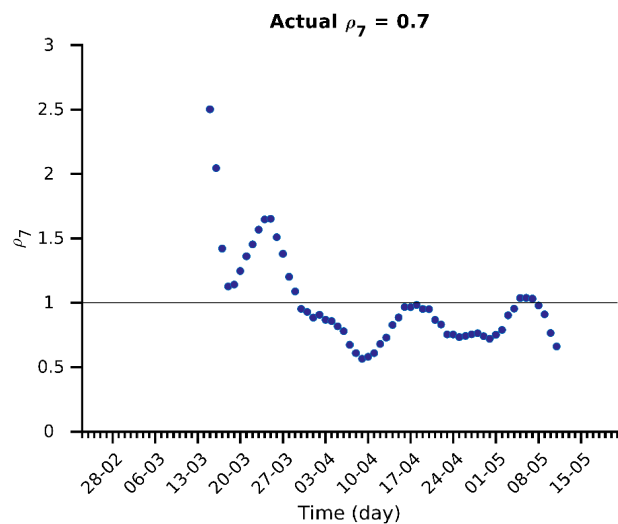
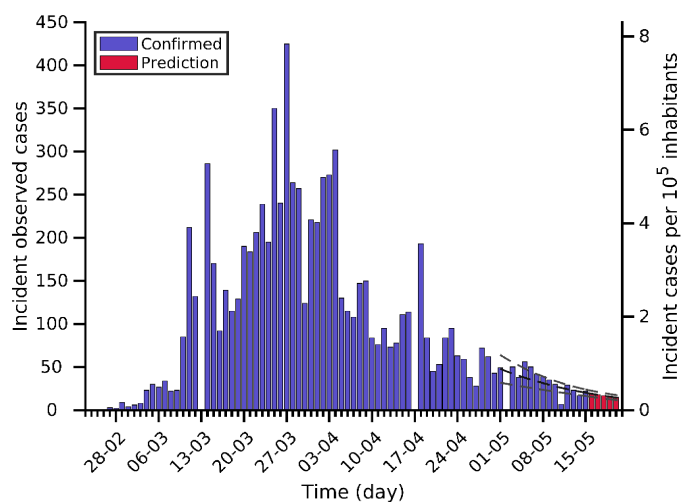
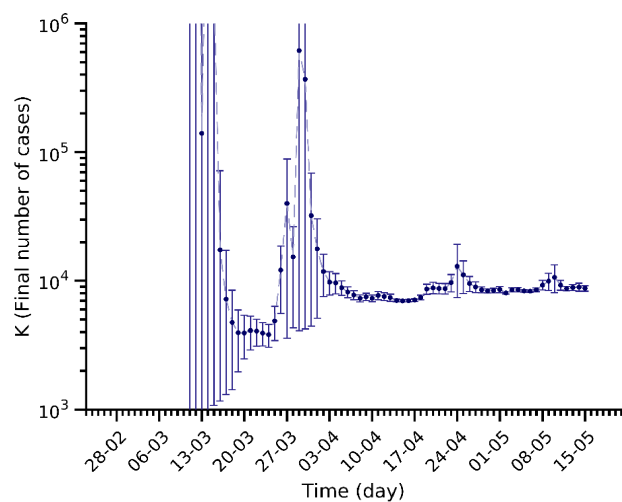
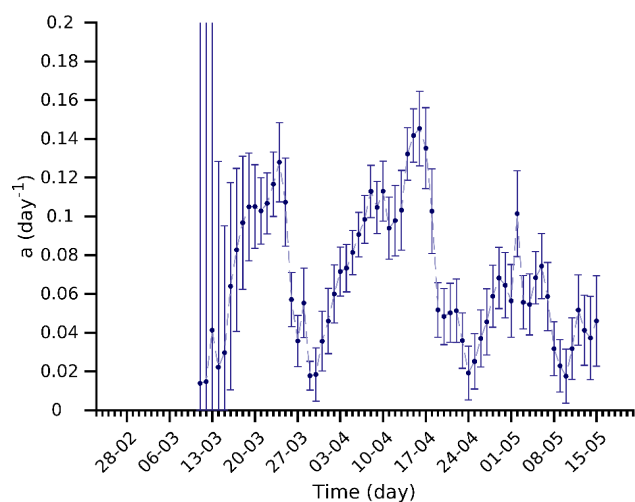
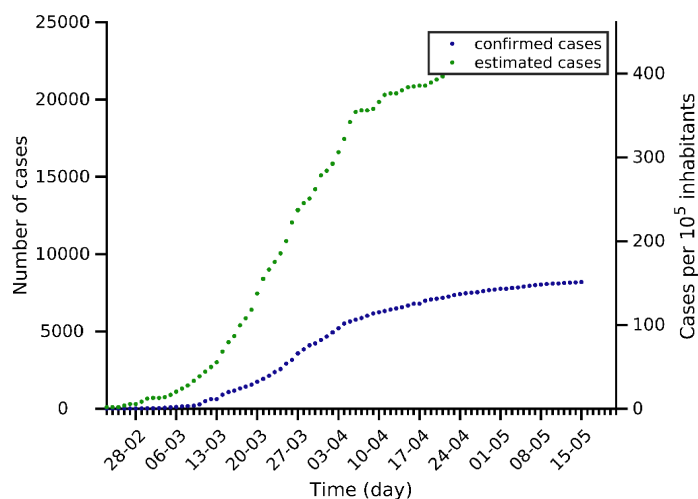
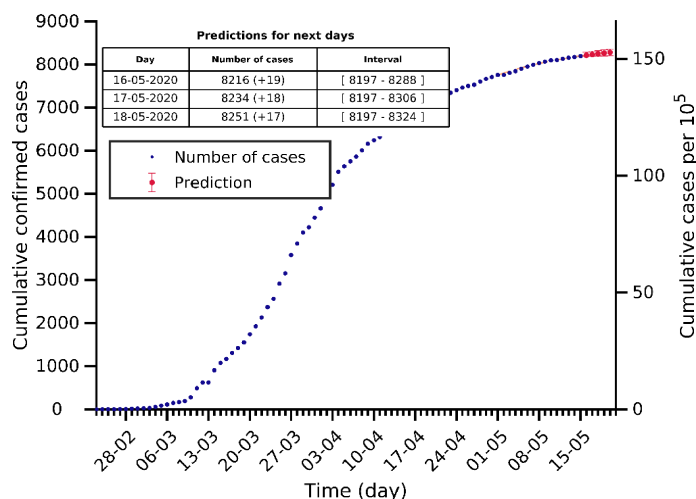
Denmark 15-05-2020. Population: 5.8M. Current cumulated incidence: 186/10⁵



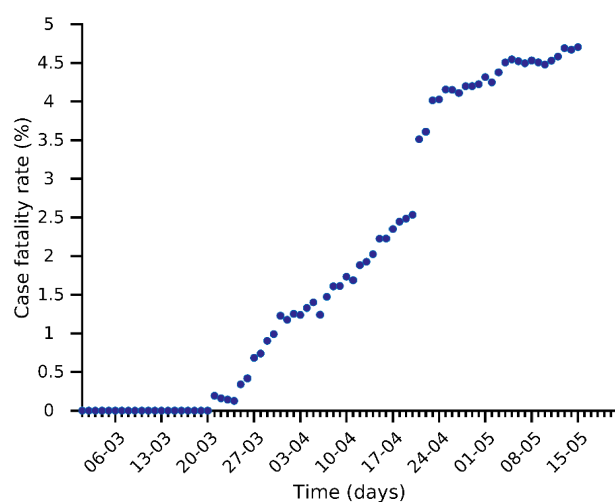
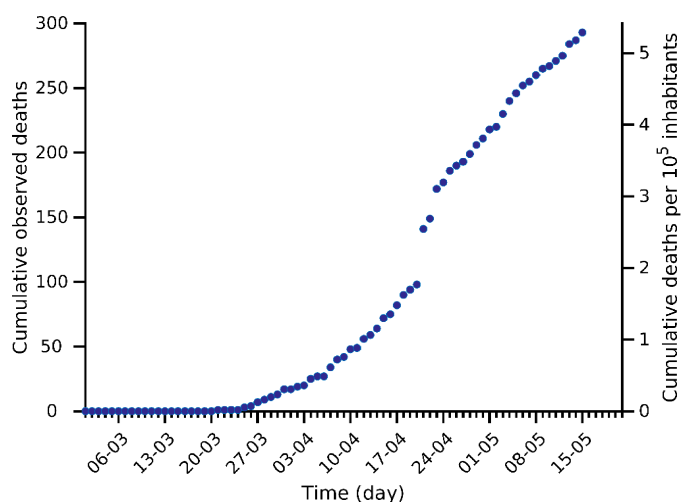
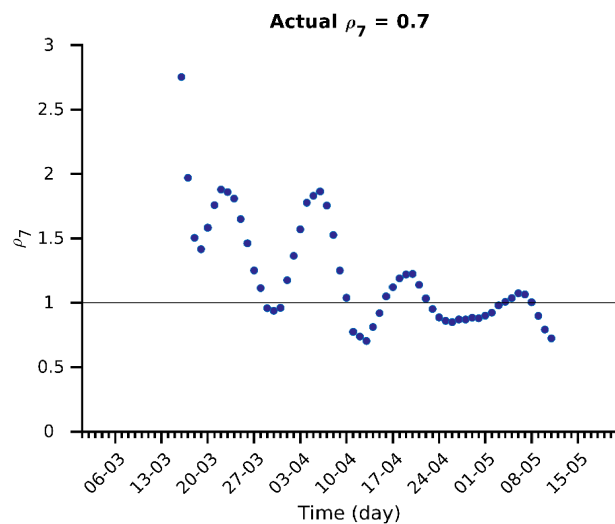
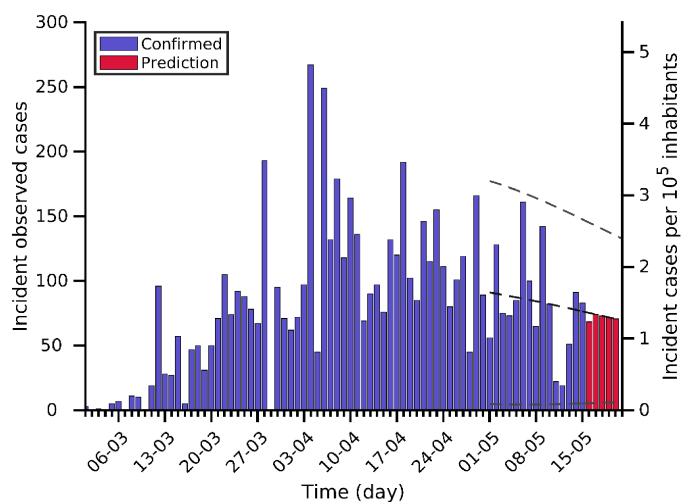
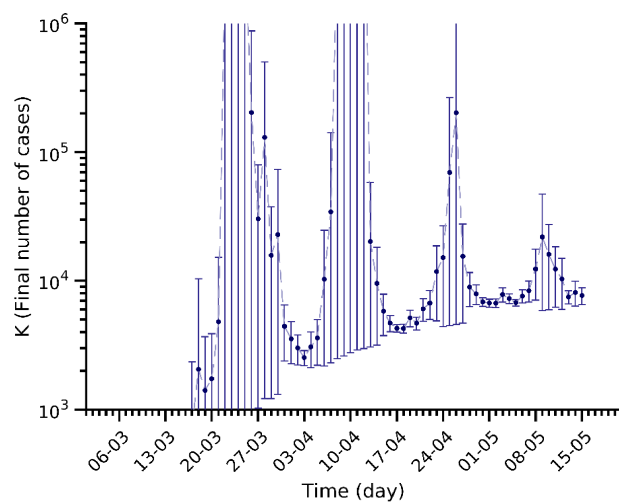
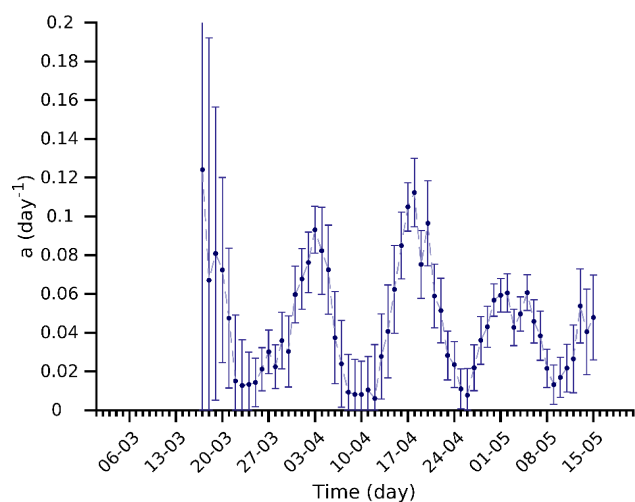
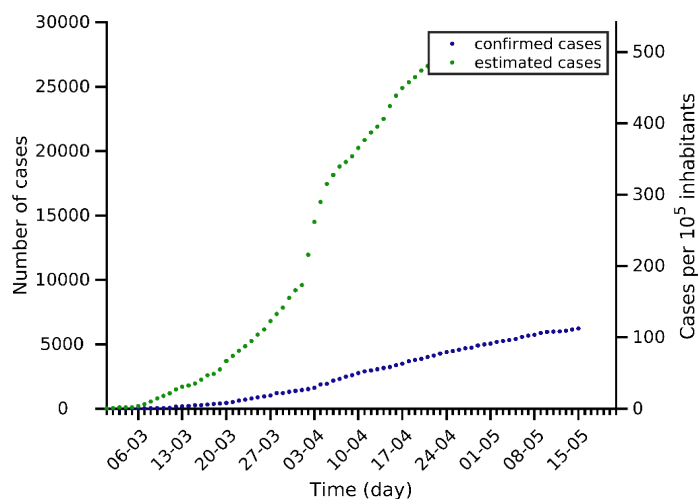
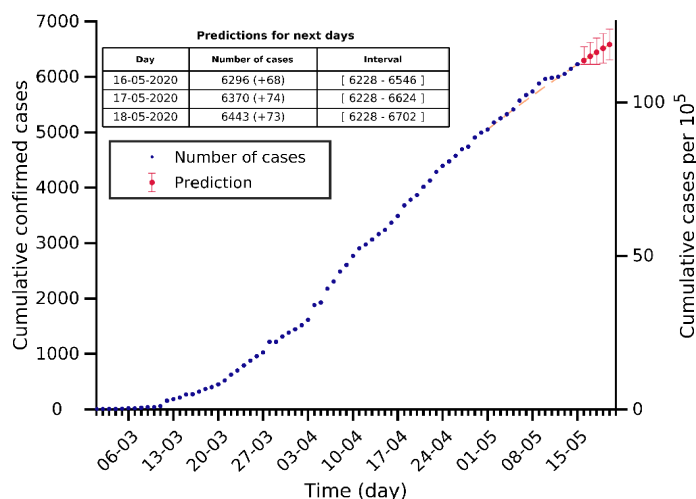
Czech Rep 15-05-2020. Population: 10.7M. Current cumulated incidence: 78/10⁵



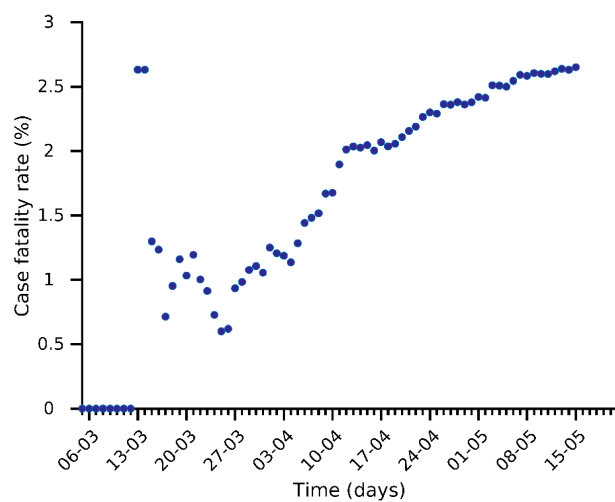
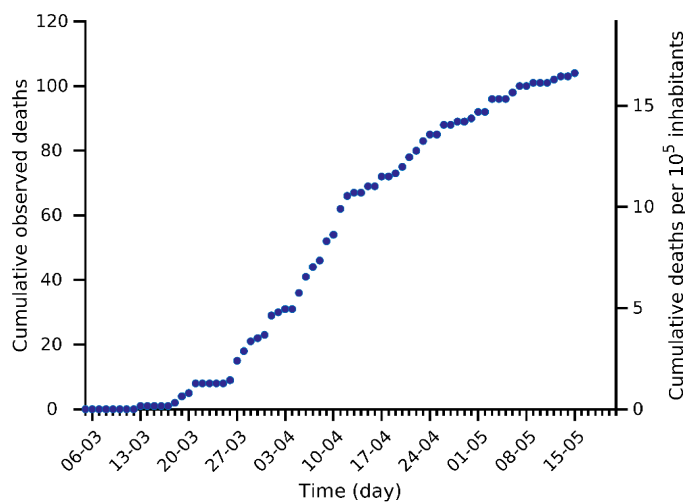
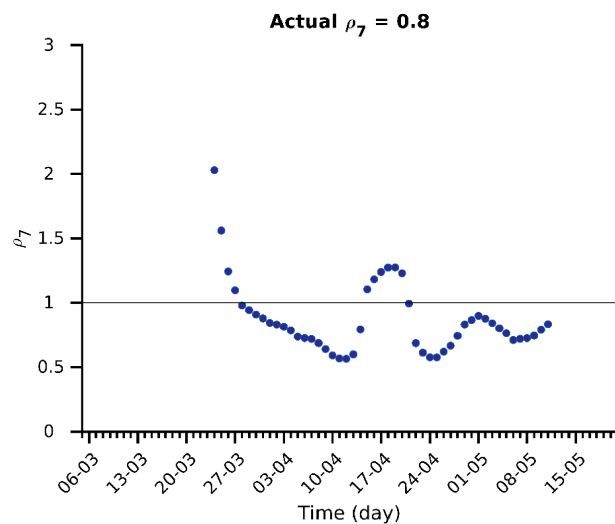
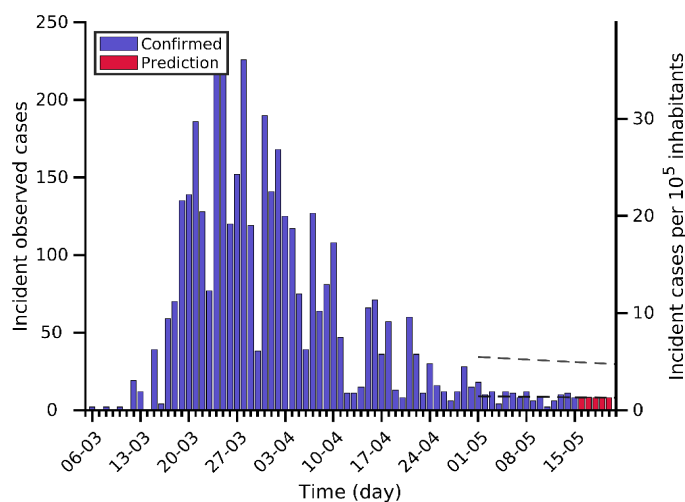
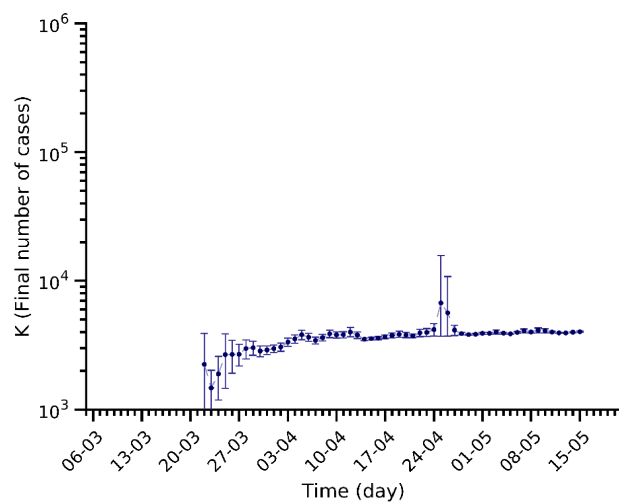
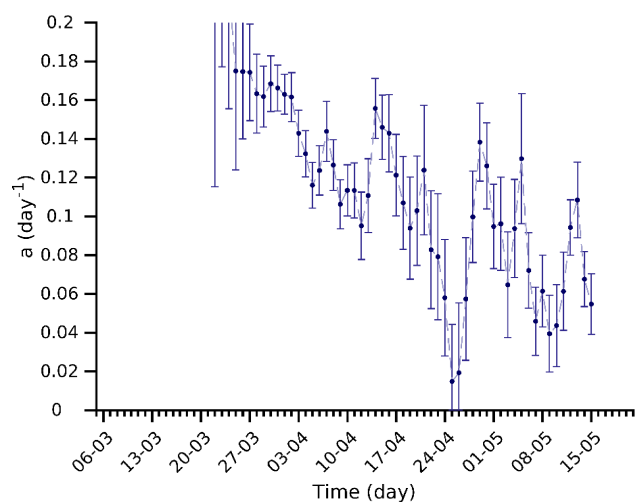
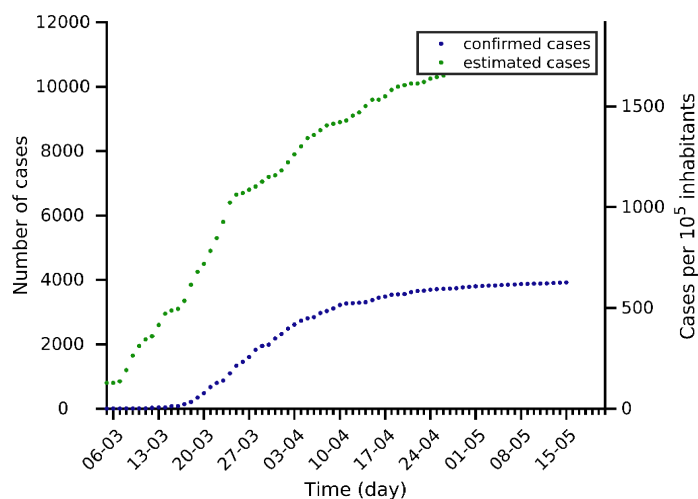
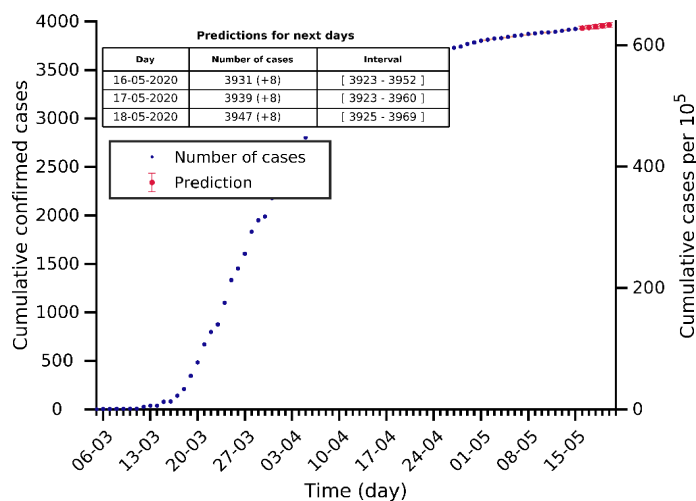
Norway 15-05-2020. Population: 5.4M. Current cumulated incidence: 151/10⁵



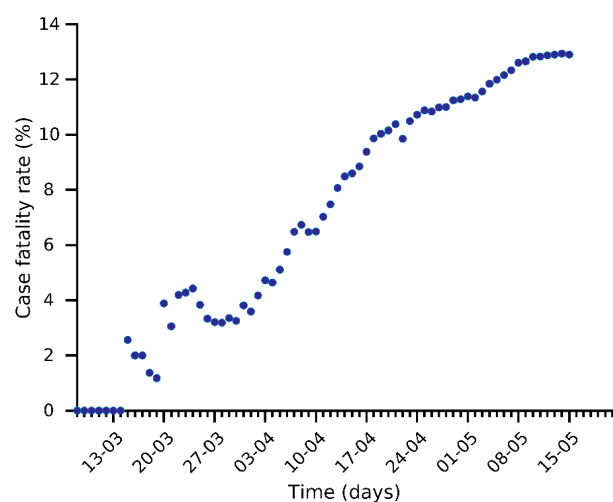
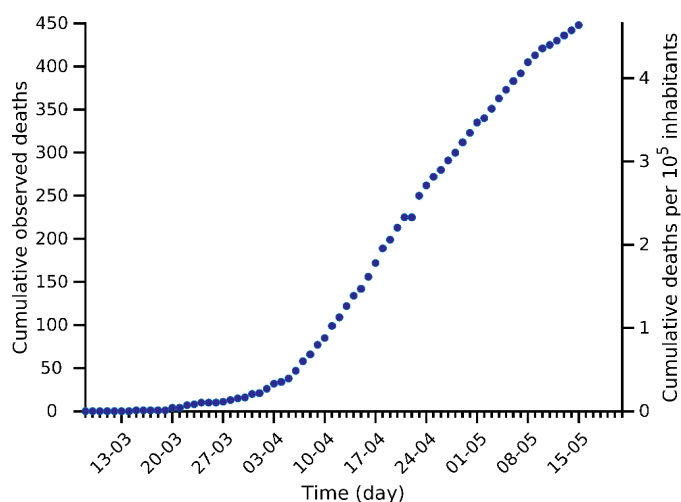
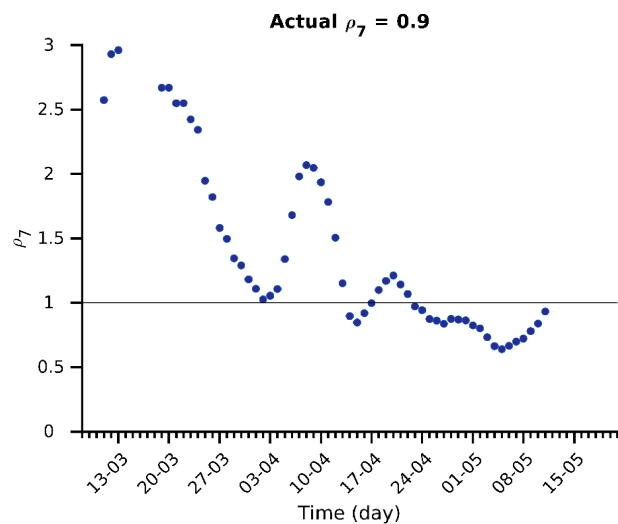
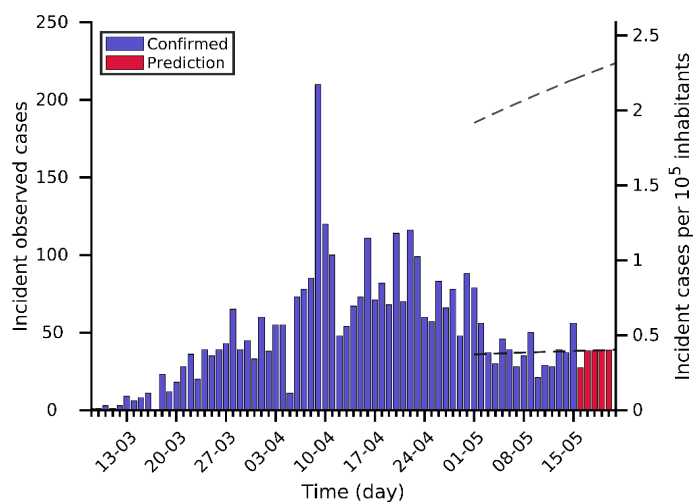
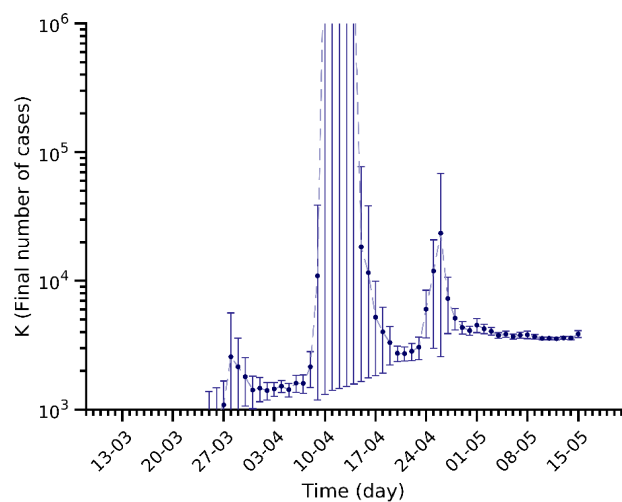
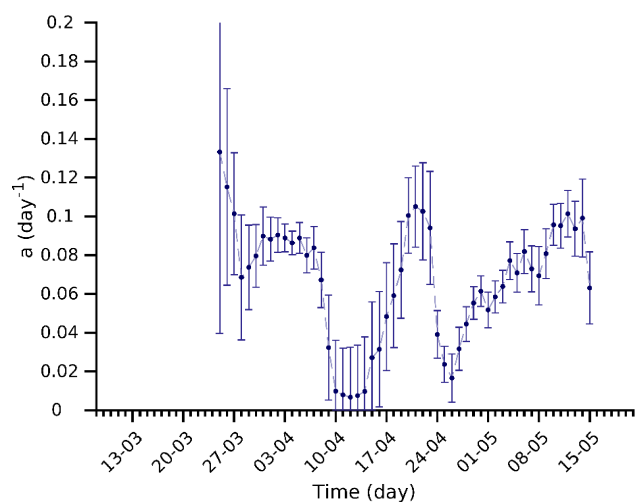
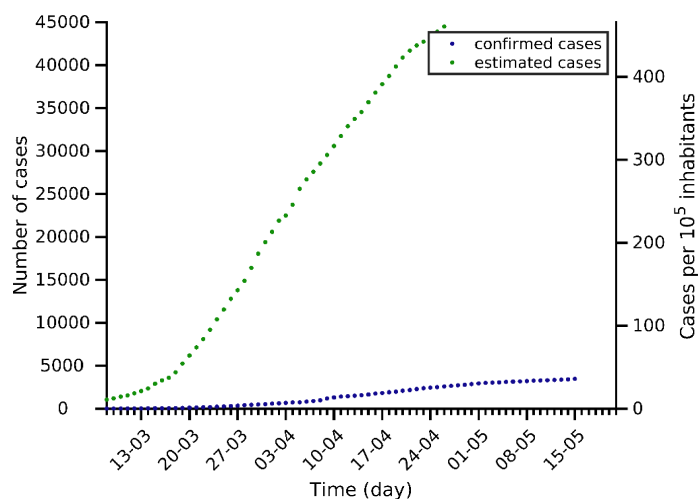
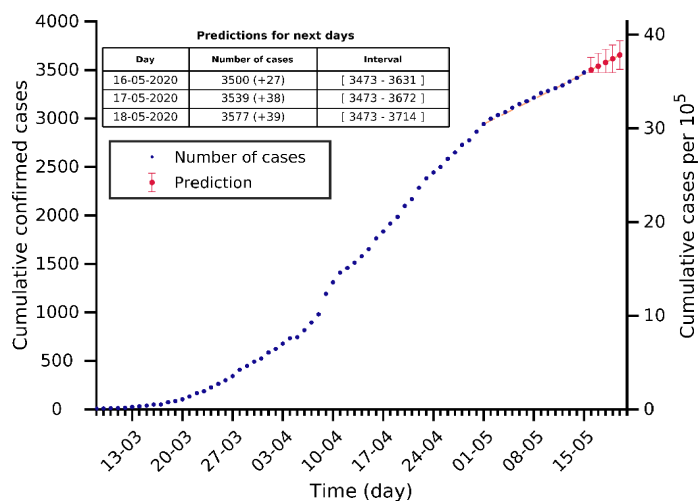
Finland 15-05-2020. Population: 5.5M. Current cumulated incidence: 112/10⁵



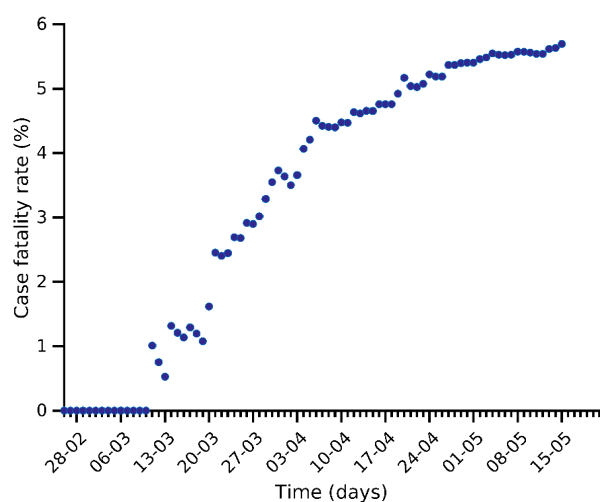
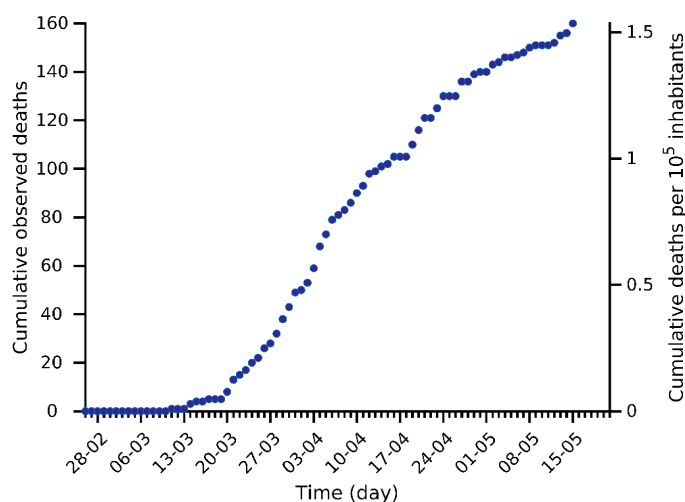
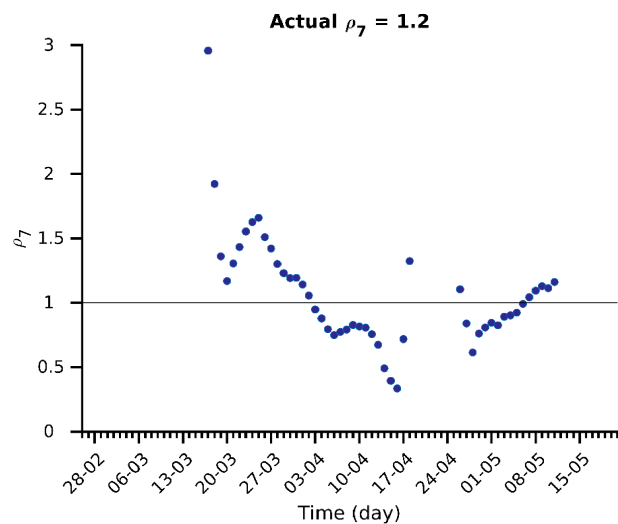
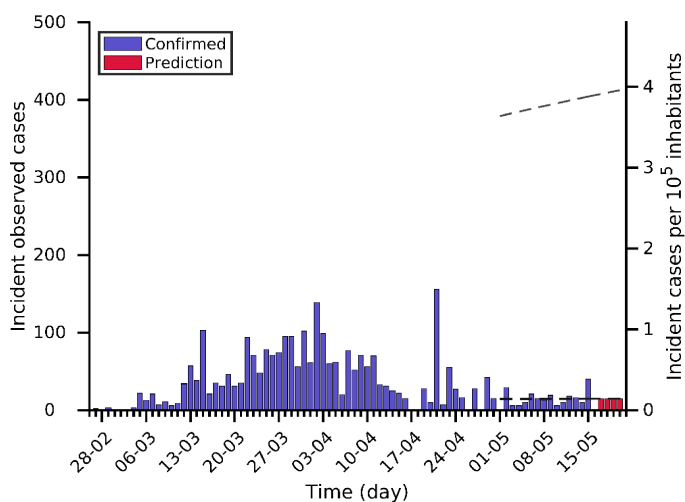
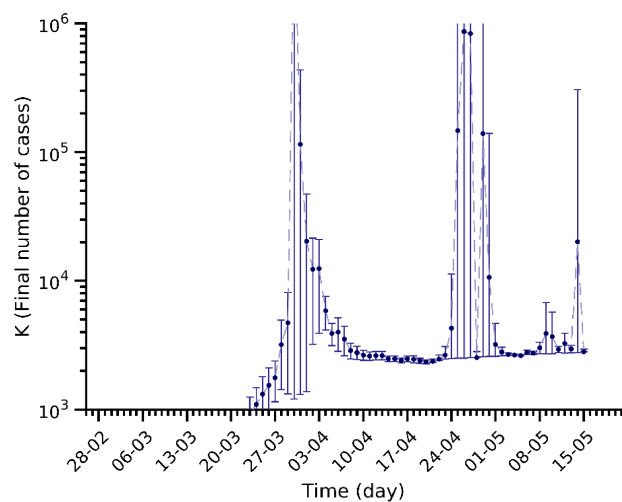
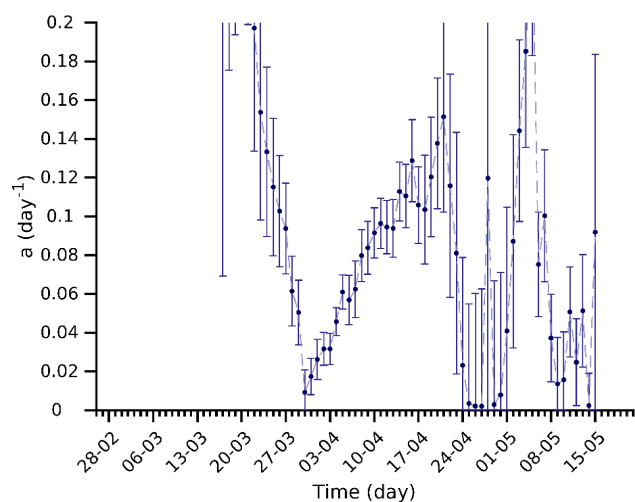
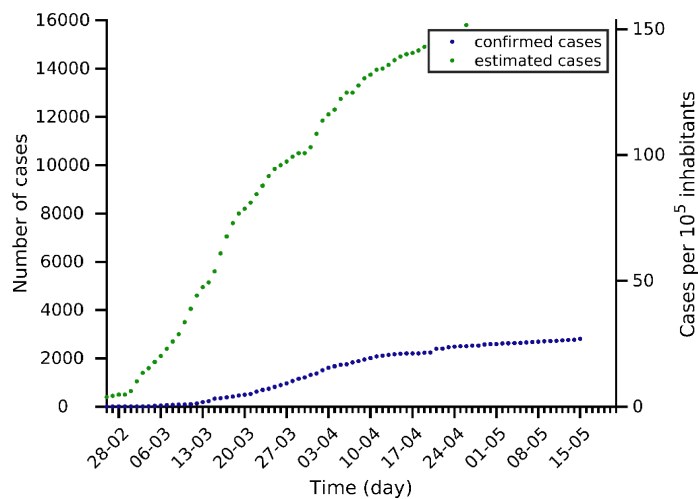
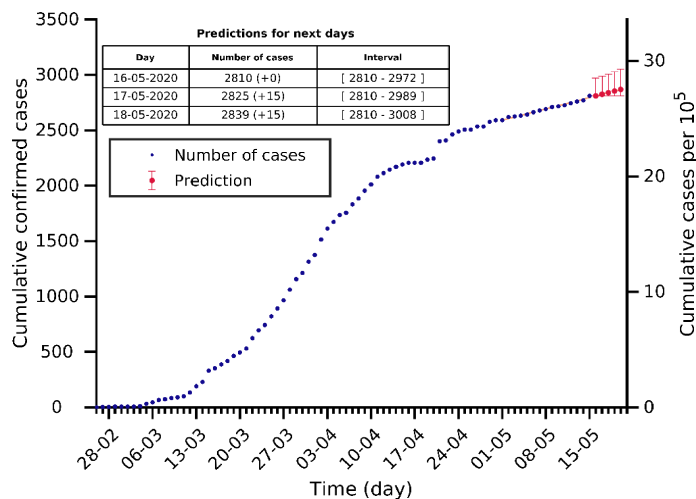
Luxembourg 15-05-2020. Population: 0.6M. Current cumulated incidence: 627/10⁵



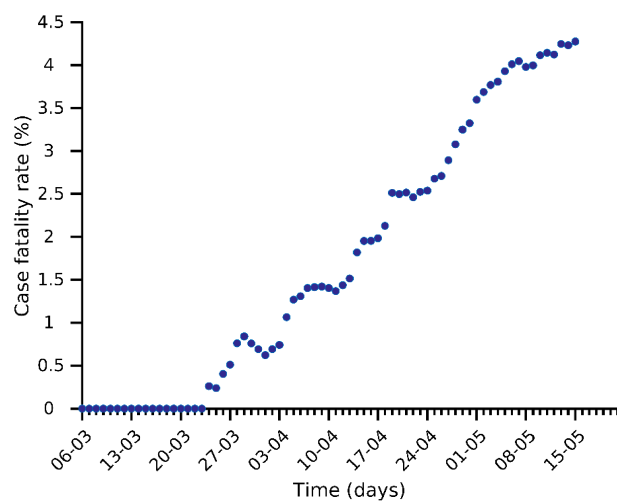
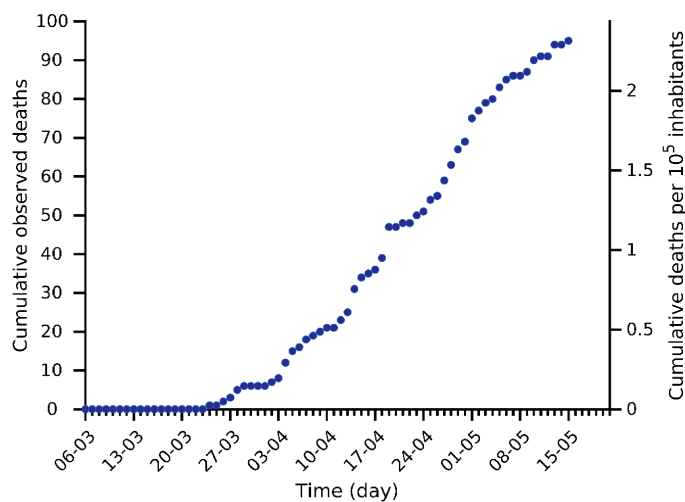
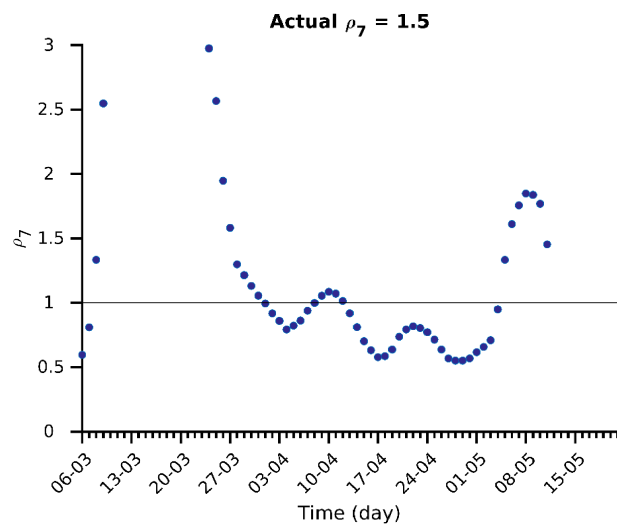
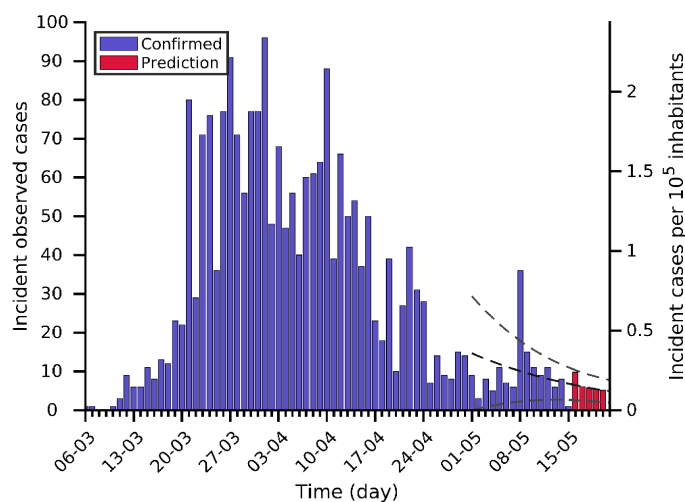
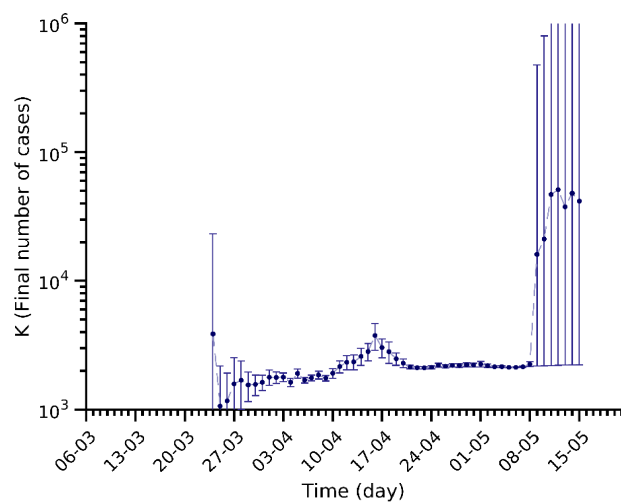
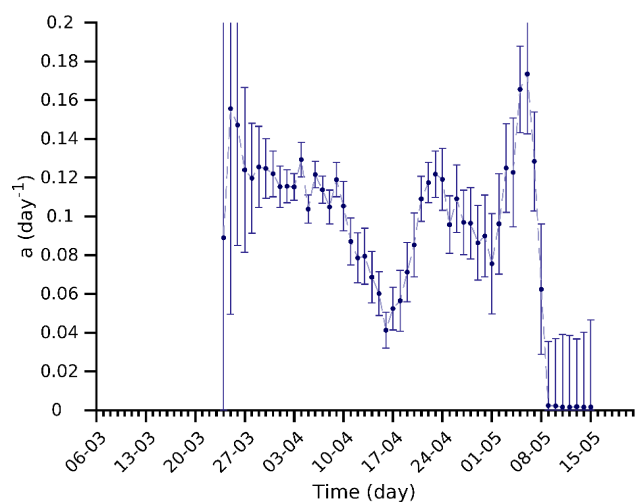
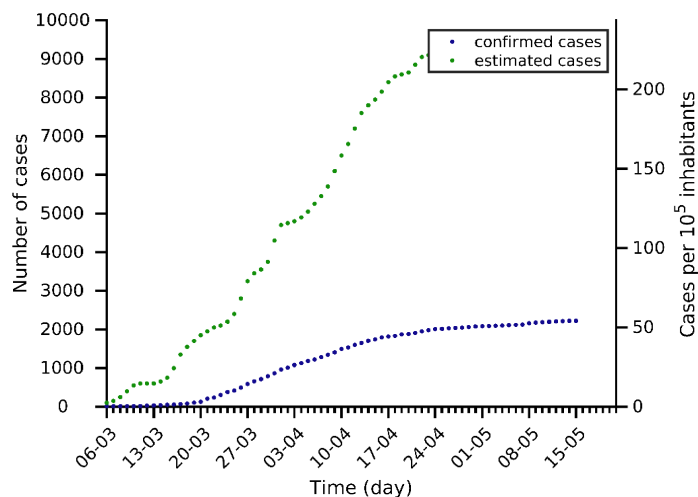
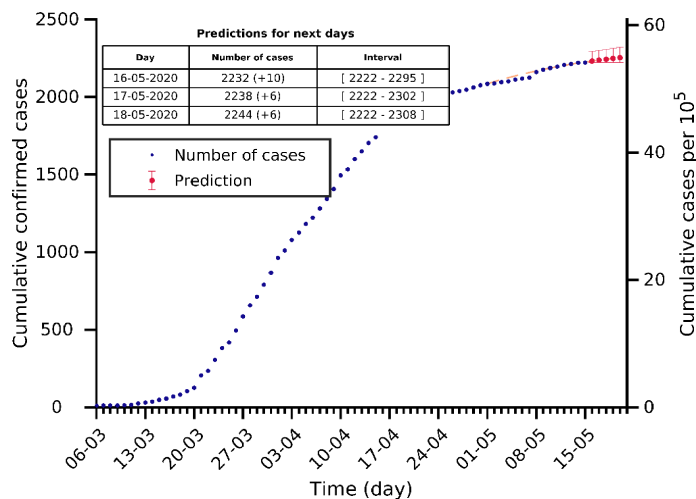
Hungary 15-05-2020. Population: 9.7M. Current cumulated incidence: 36/10⁵



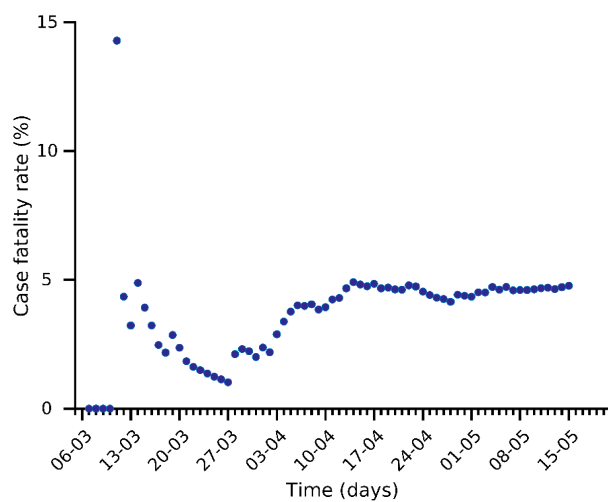
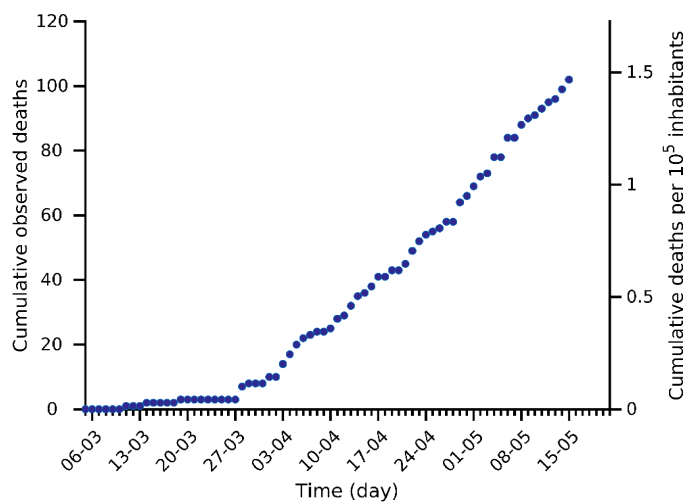
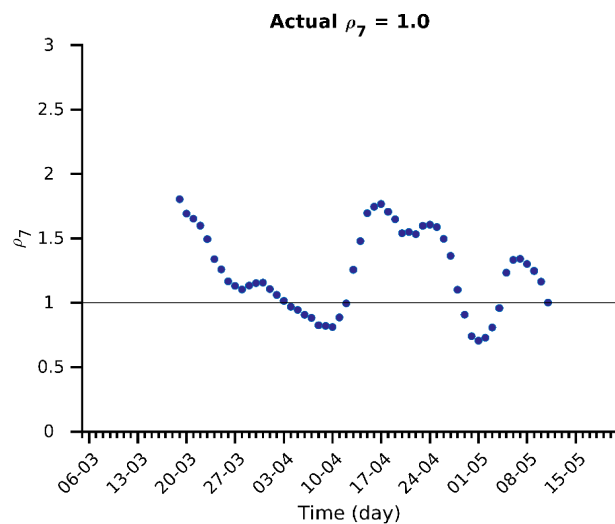
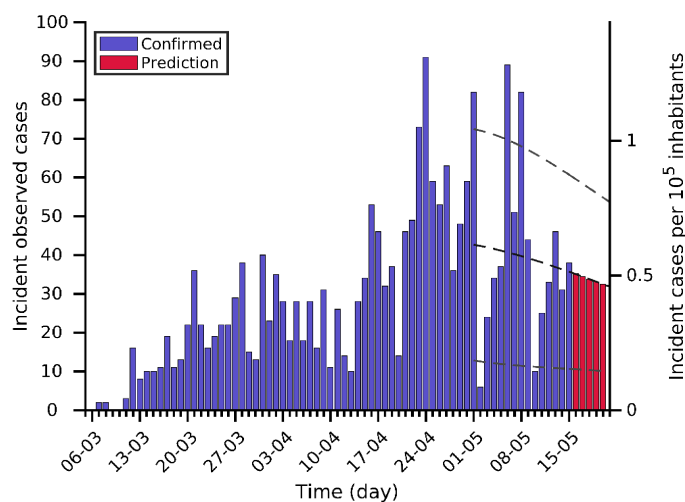
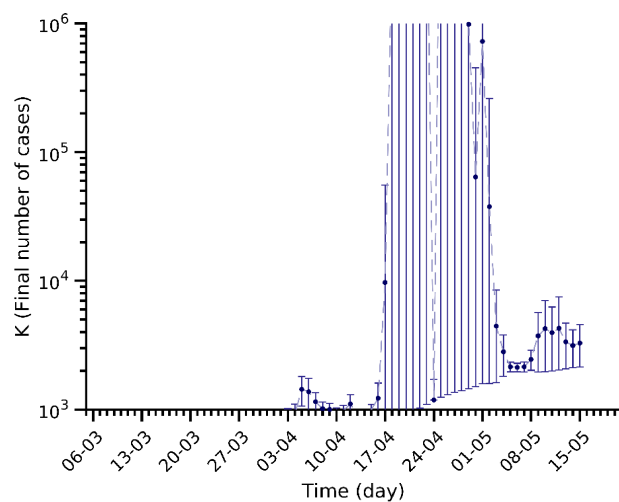
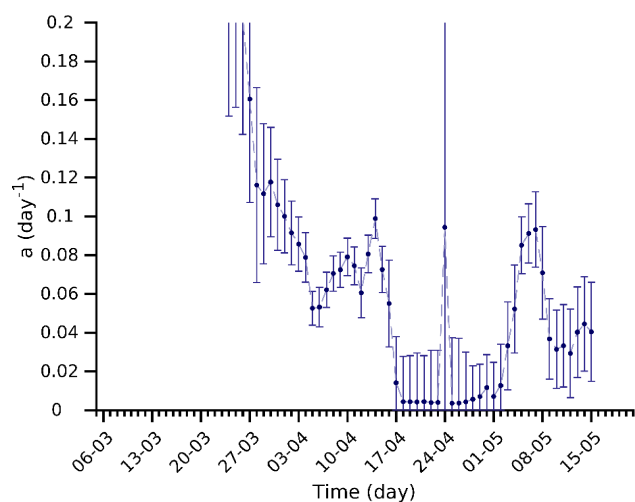
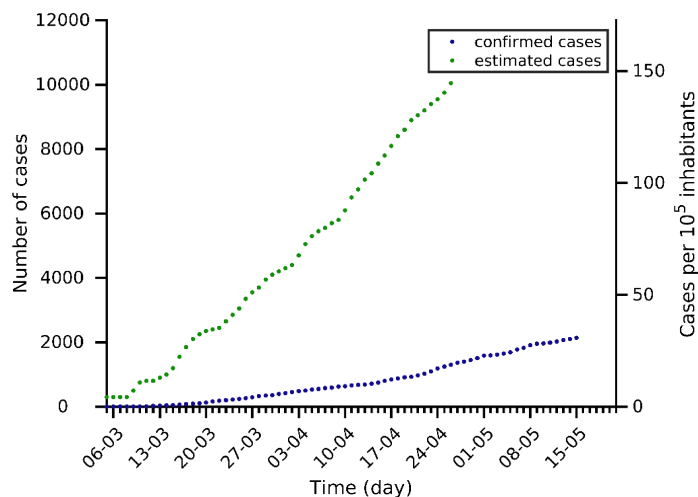
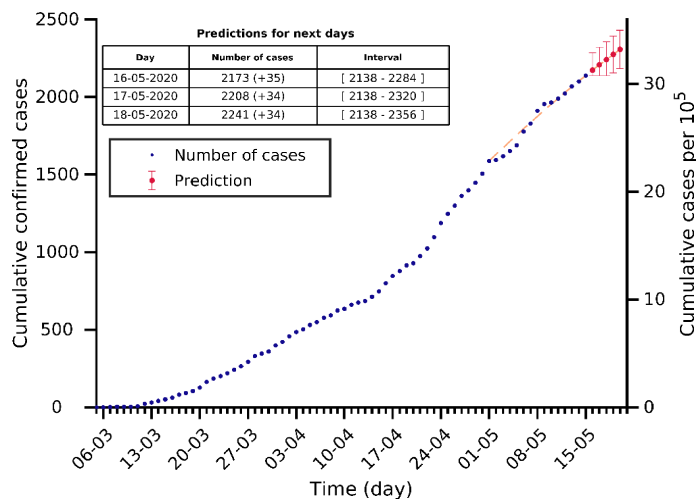
Greece 15-05-2020. Population: 10.4M. Current cumulated incidence: 27/10⁵



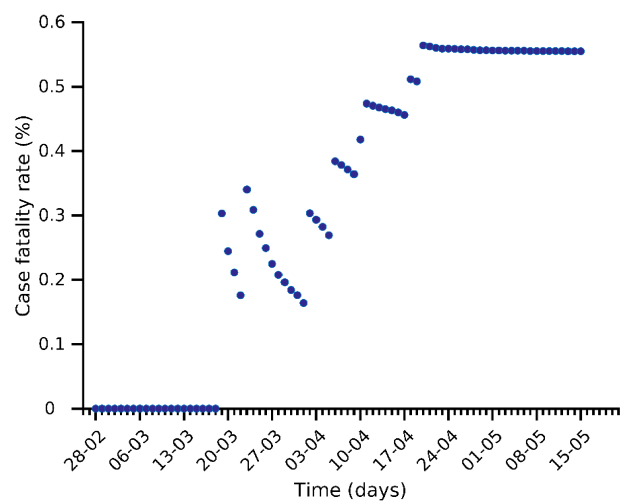
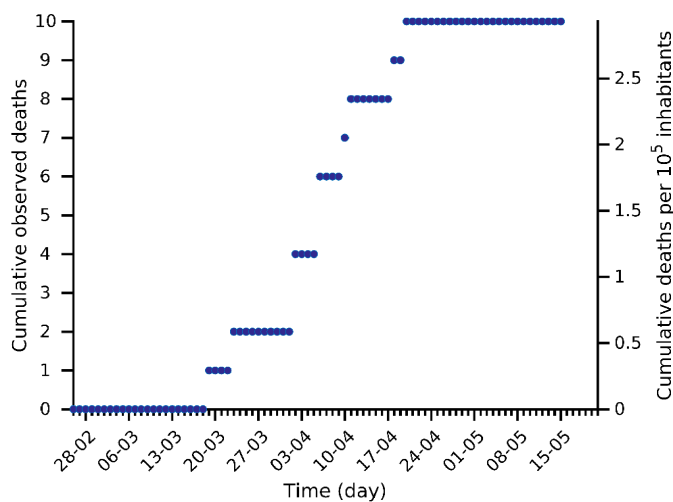
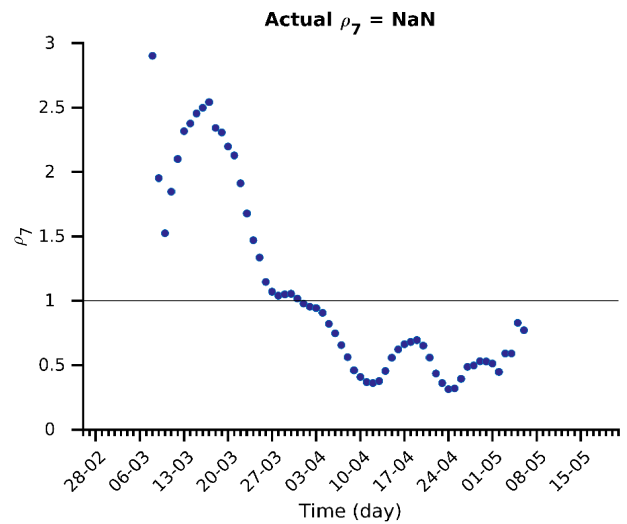
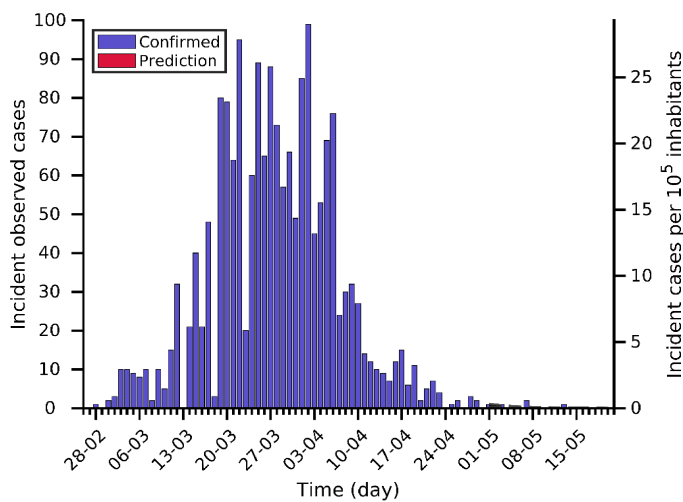
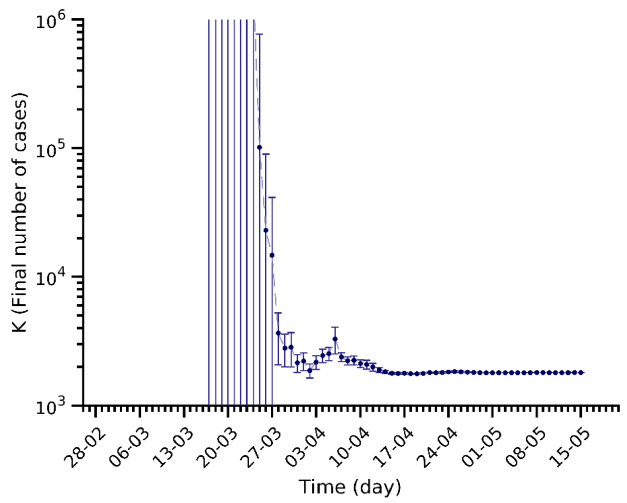
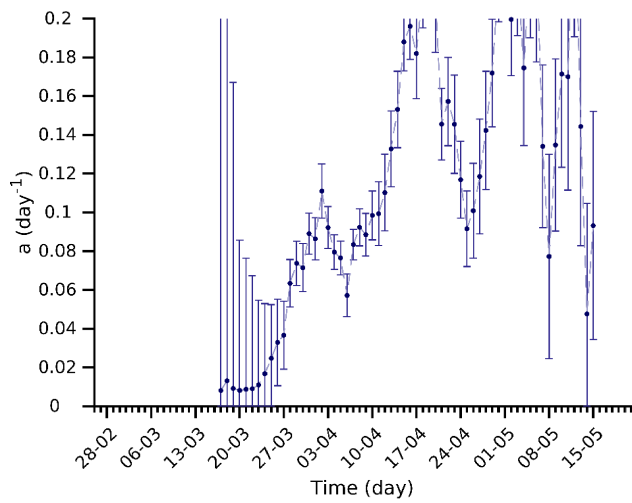
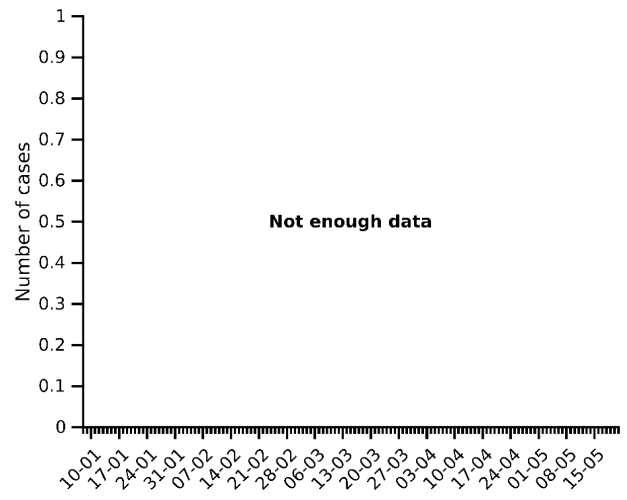
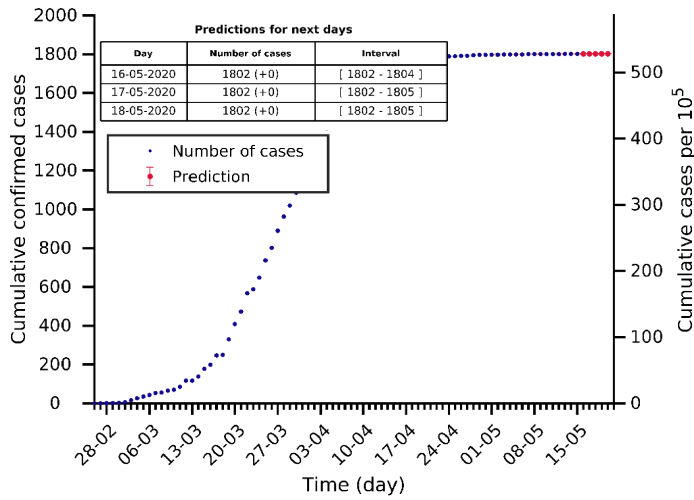
Croatia 15-05-2020. Population: 4.1M. Current cumulated incidence: 54/10⁵



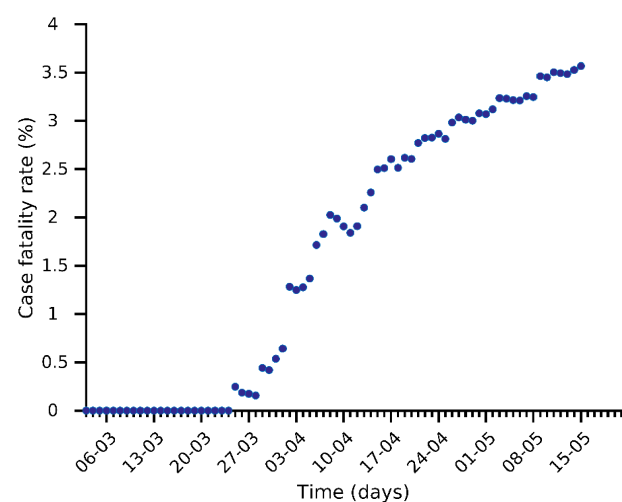
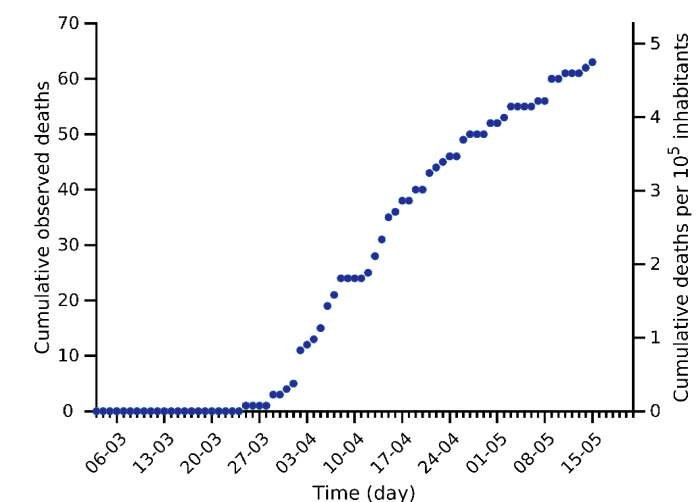
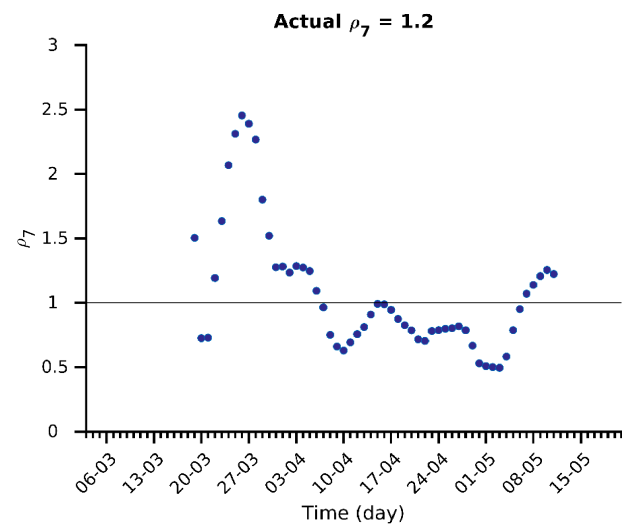
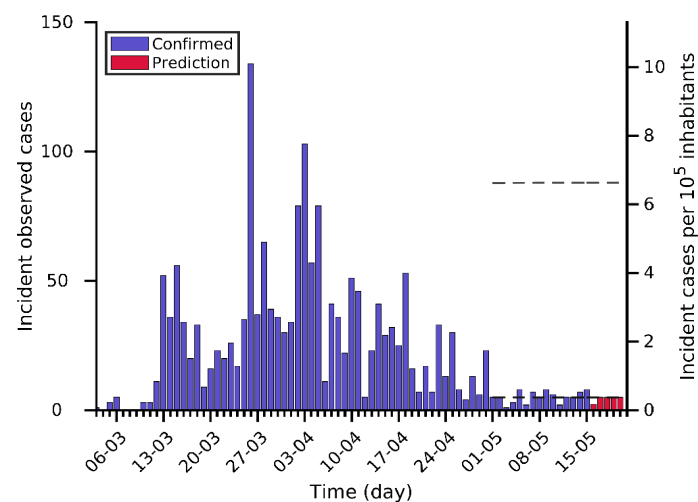
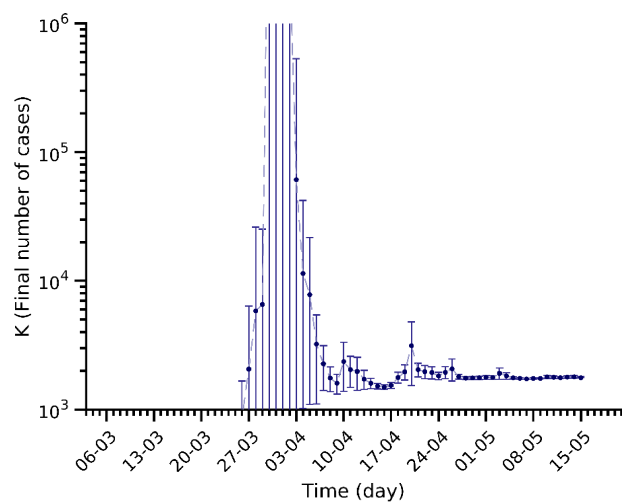
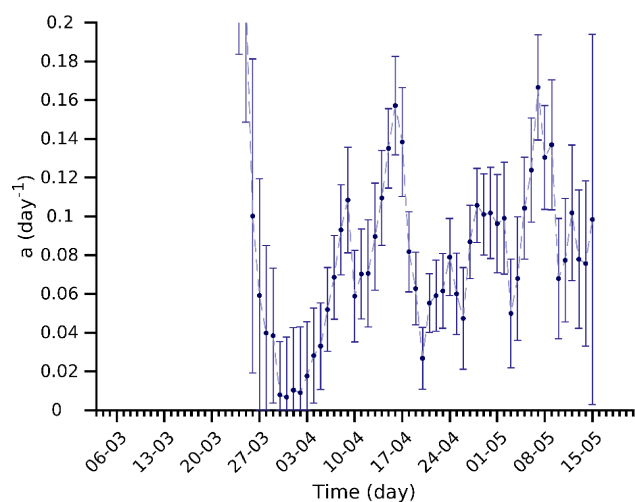
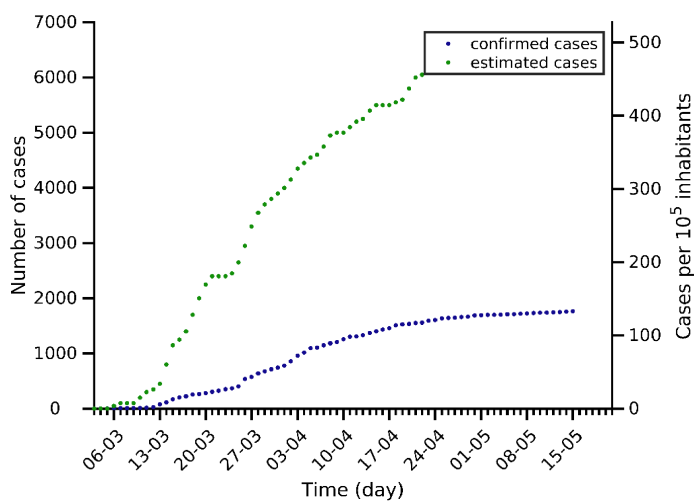
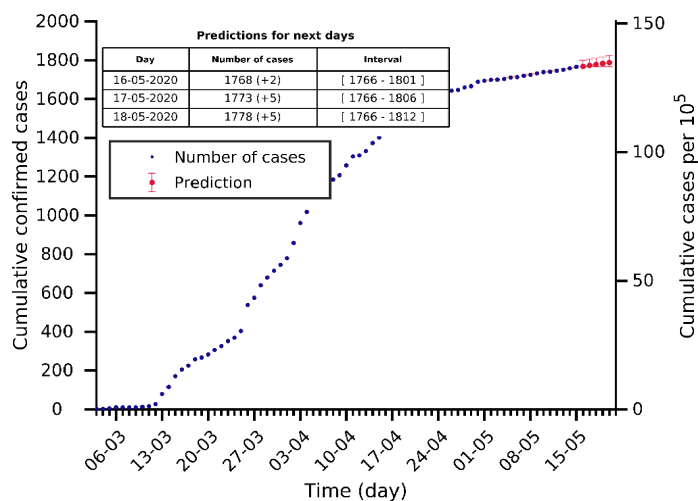
Bulgaria 15-05-2020. Population: 6.9M. Current cumulated incidence: 31/10⁵



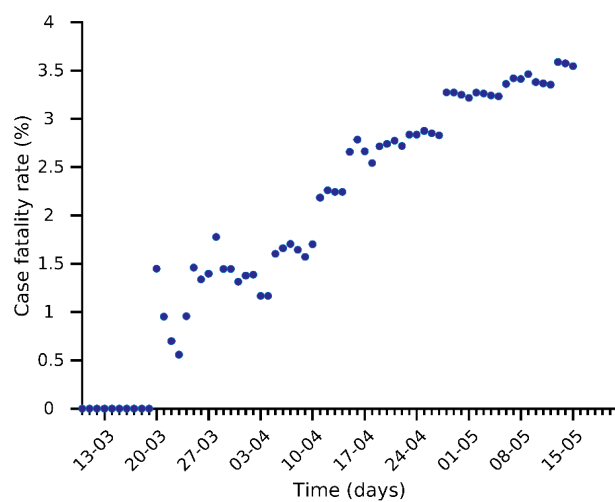
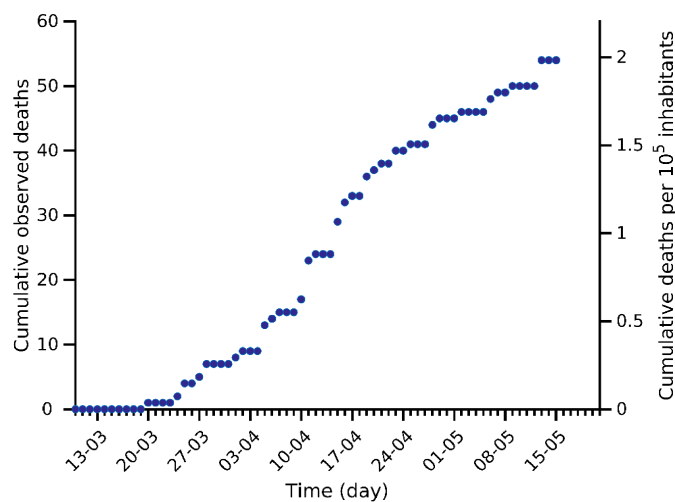
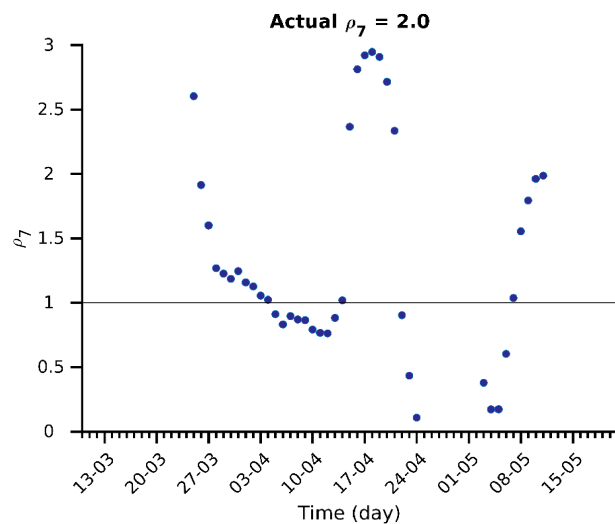
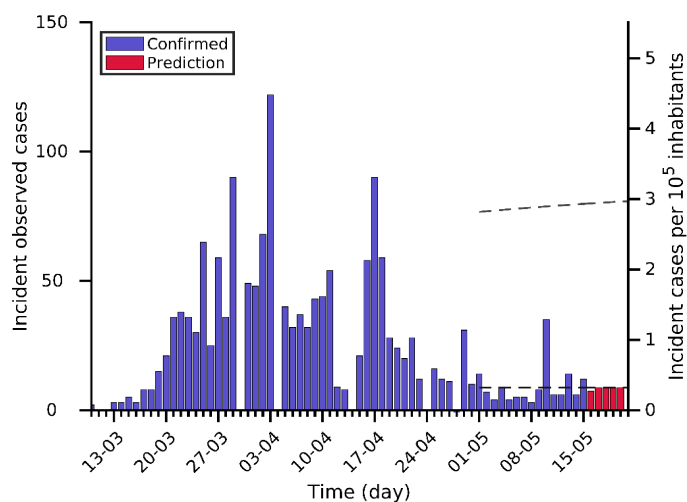
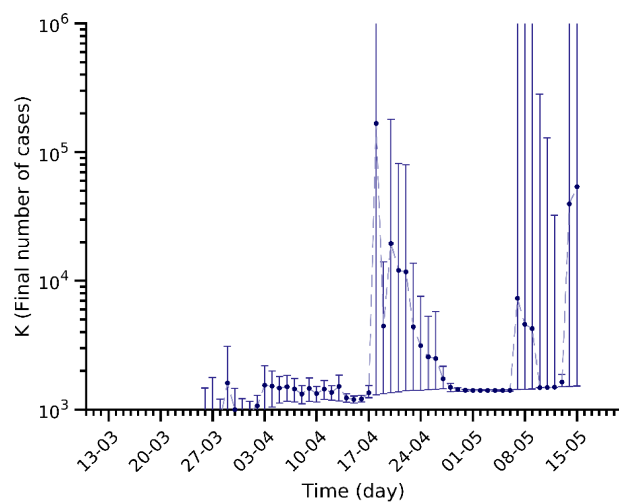
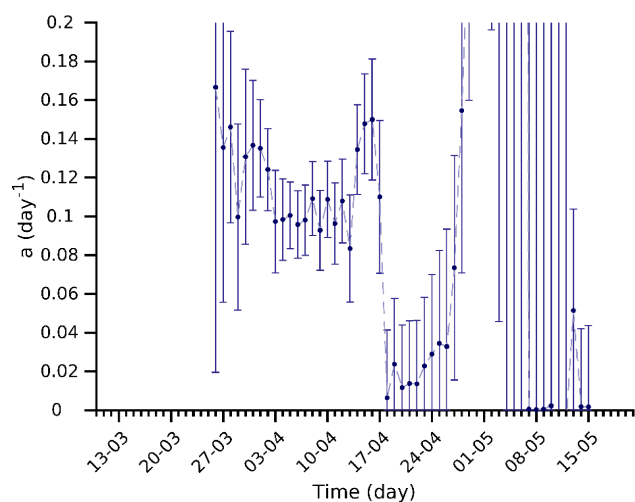
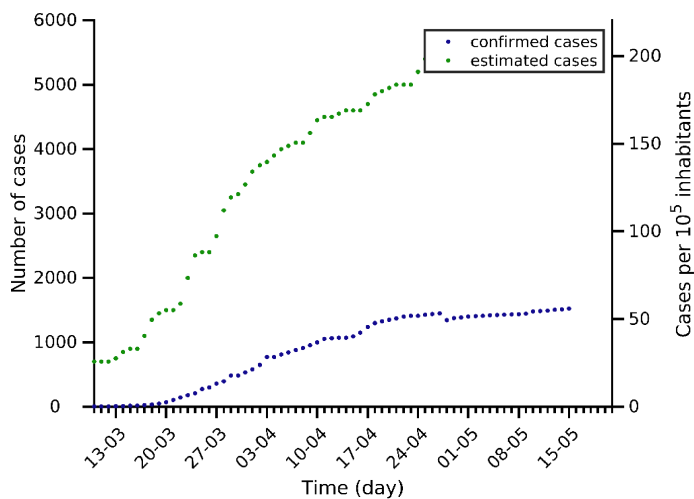
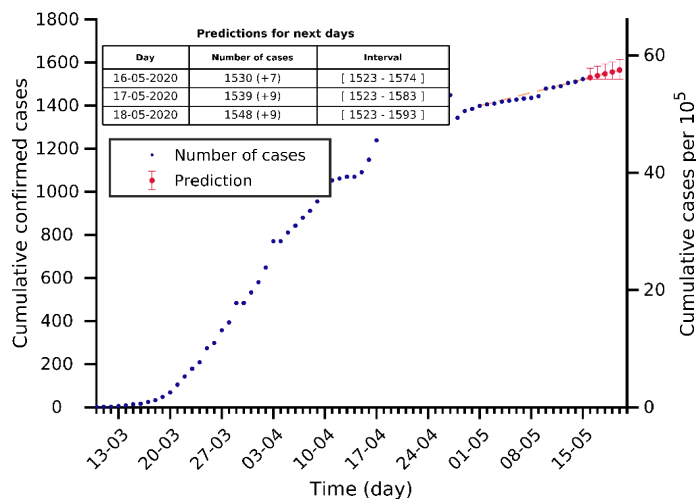
Iceland 15-05-2020. Population: 0.3M. Current cumulated incidence: 528/10⁵



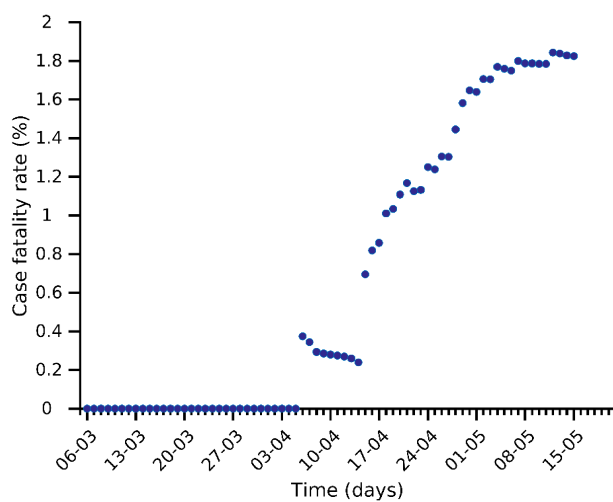
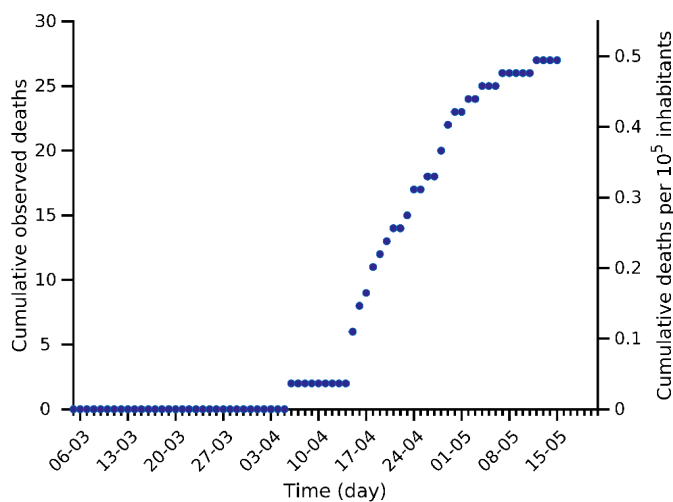
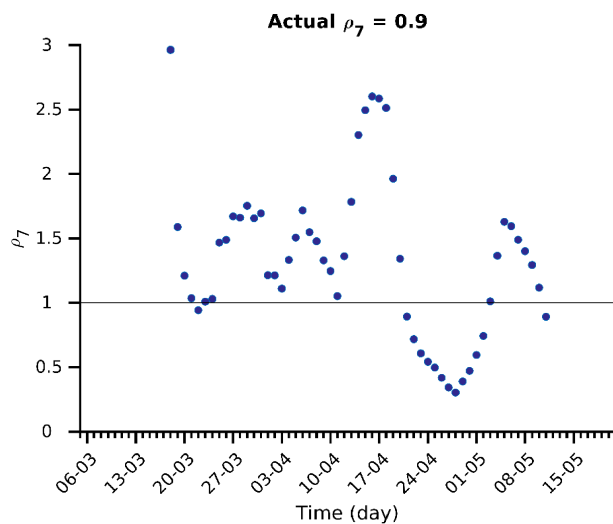
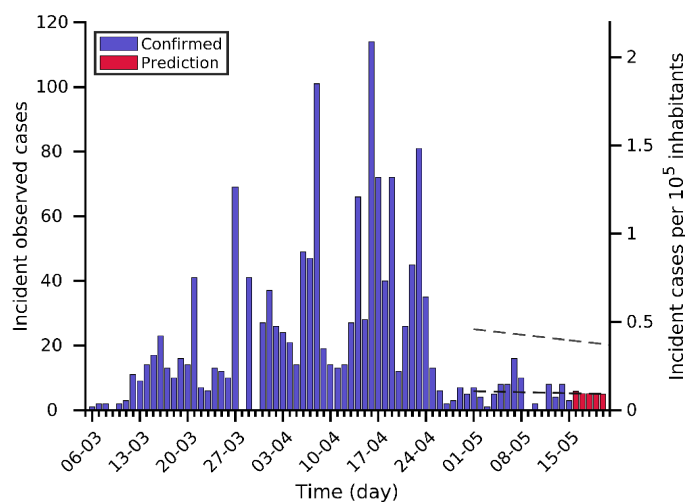
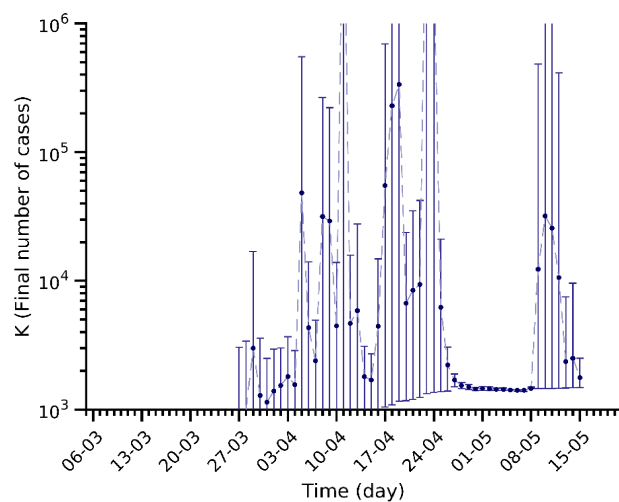
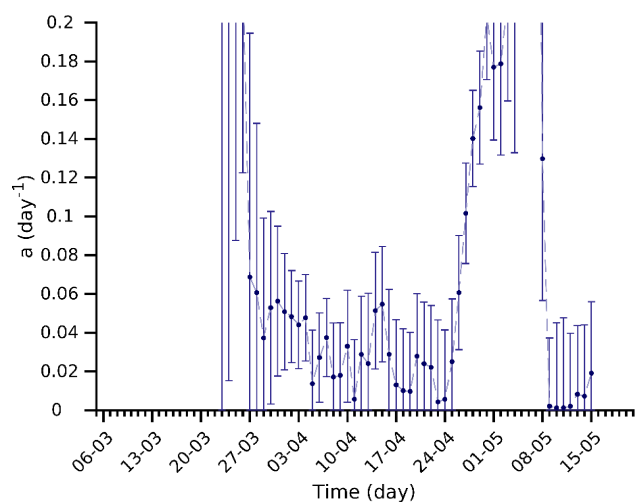
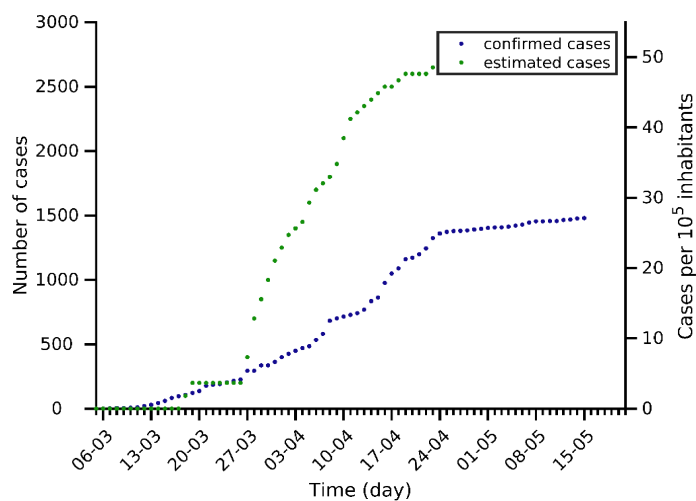
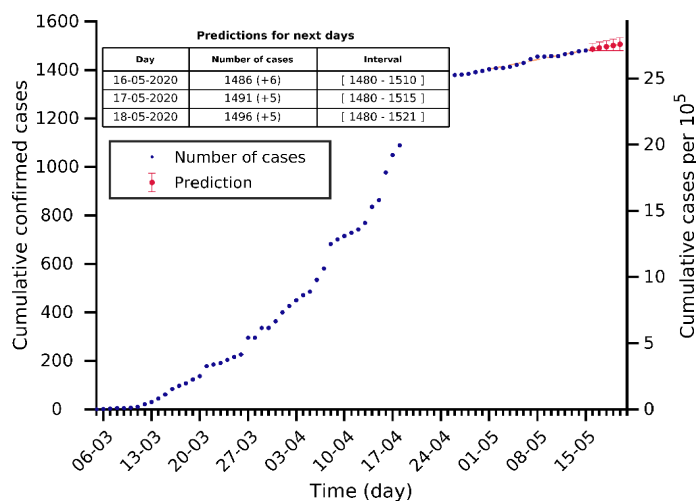
Estonia 15-05-2020. Population: 1.3M. Current cumulated incidence: 133/10⁵



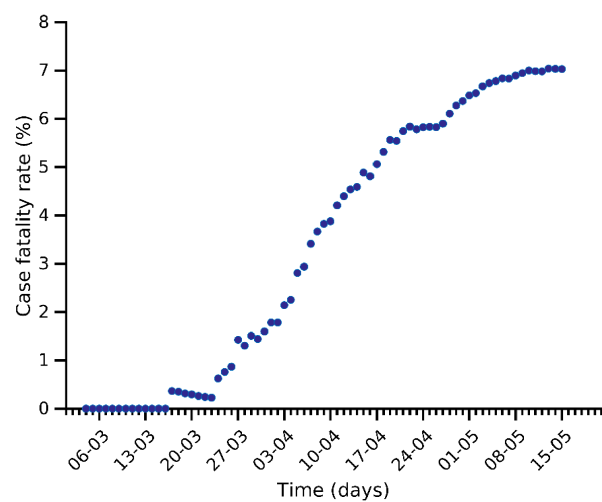
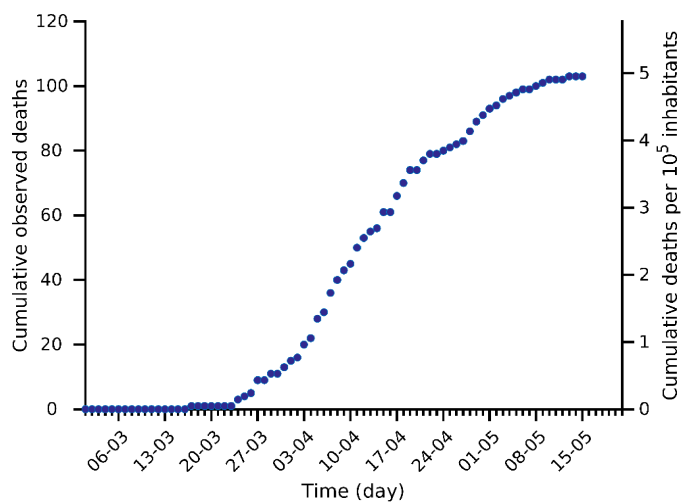
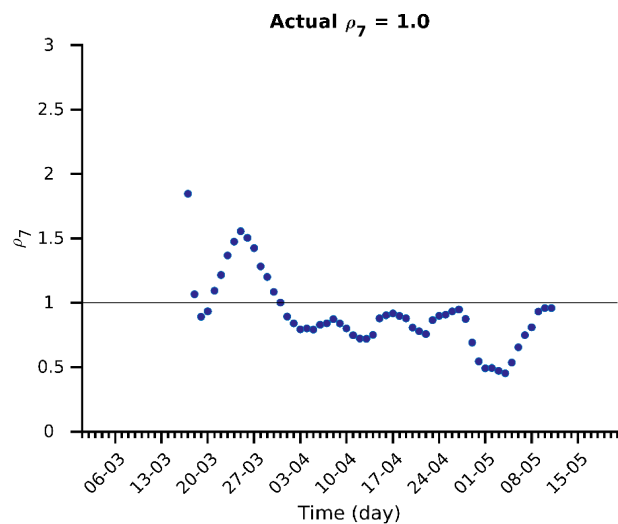
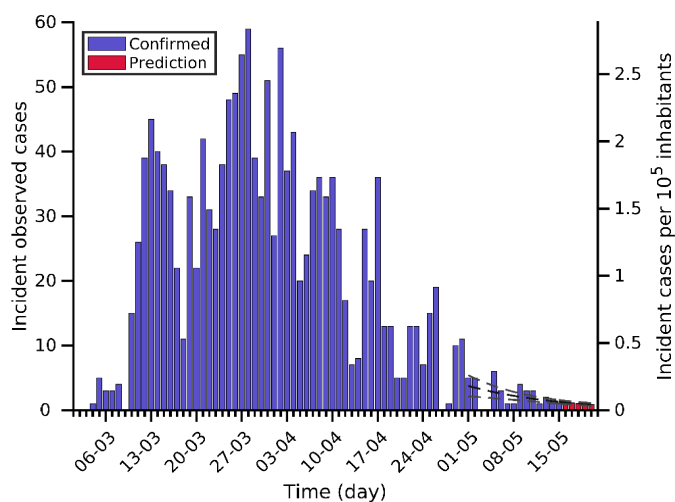
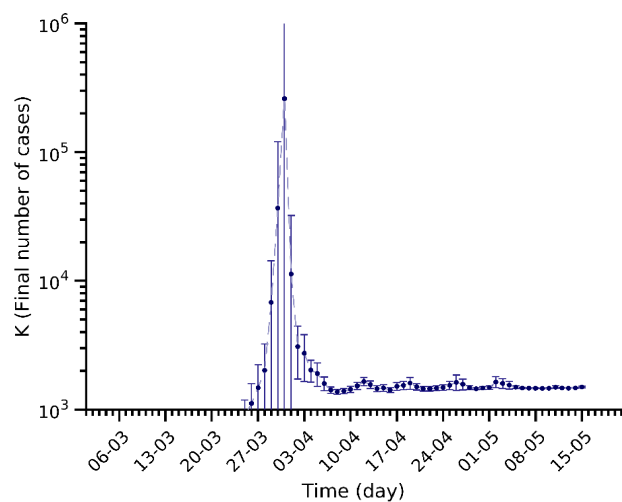
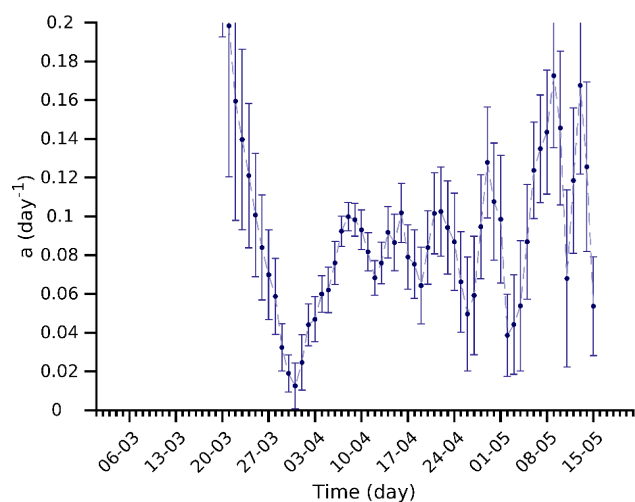
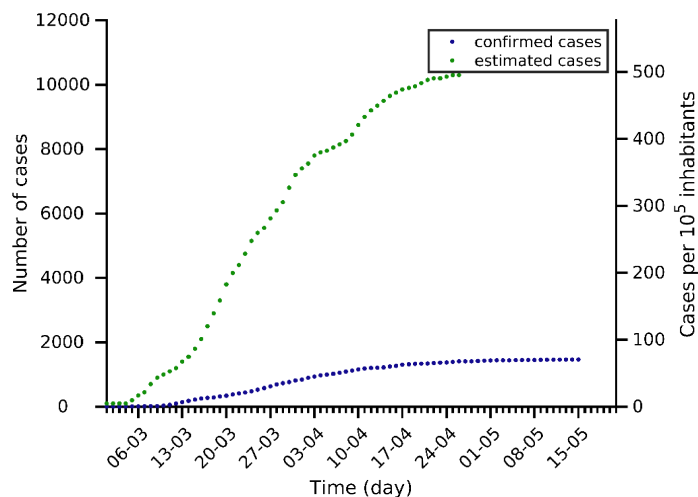
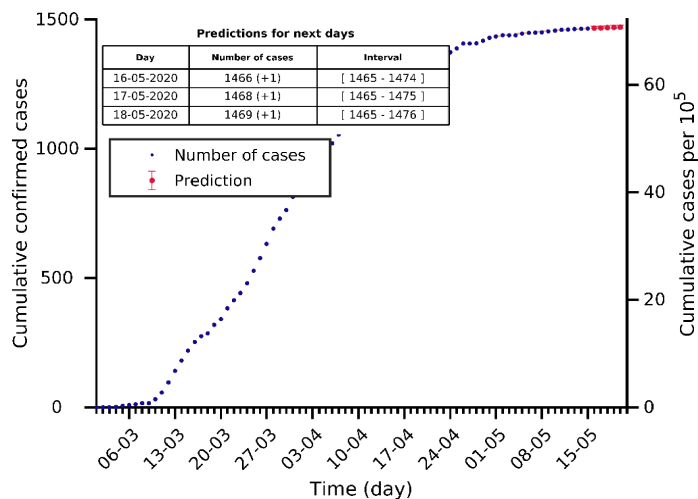
Lithuania 15-05-2020. Population: 2.7M. Current cumulated incidence: 56/10⁵



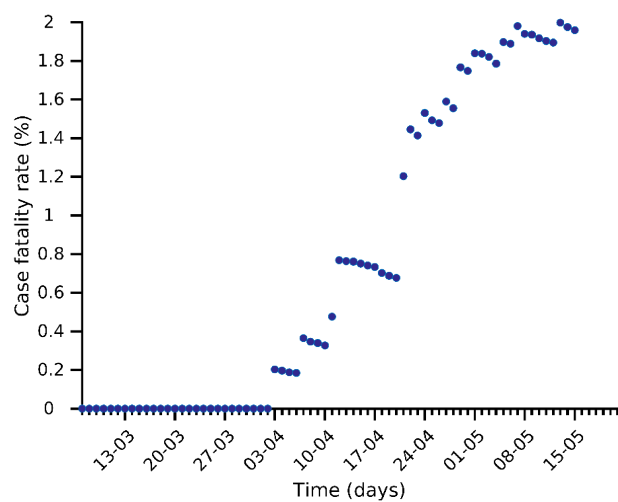
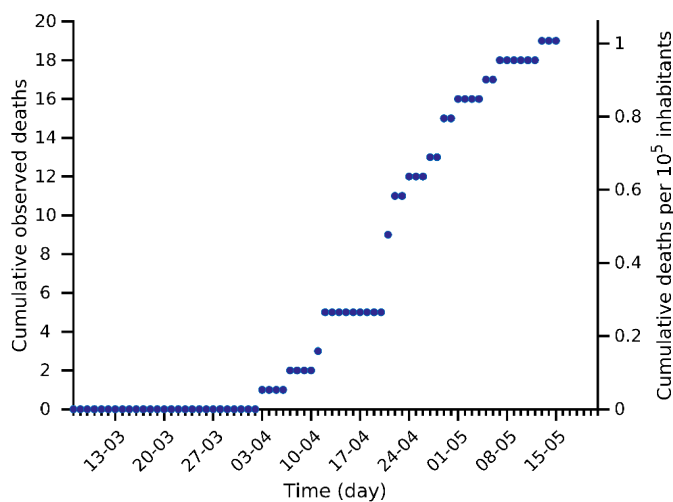
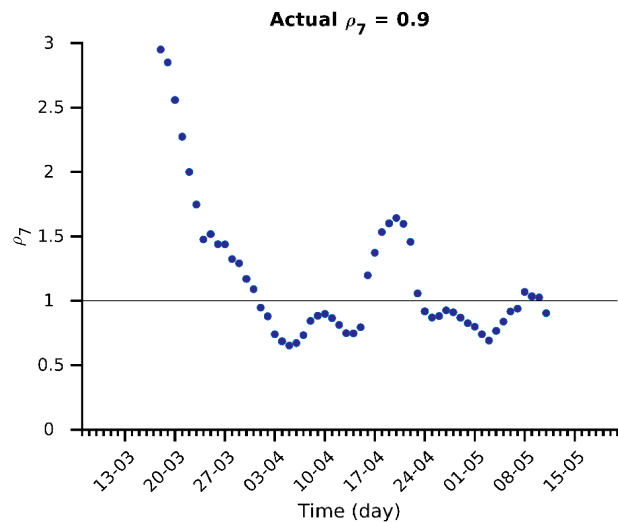
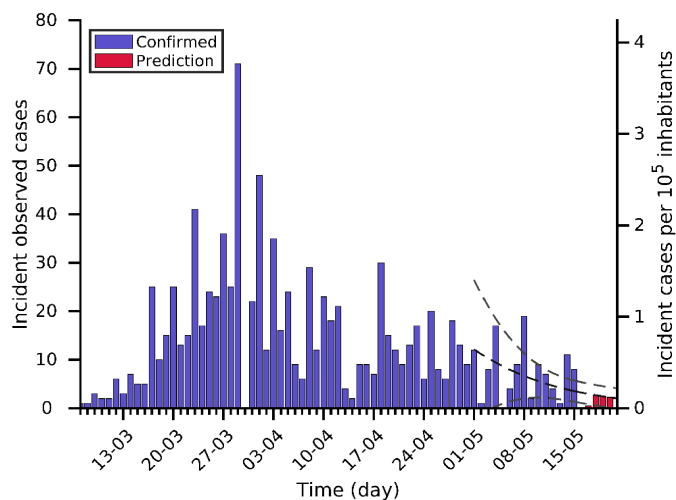
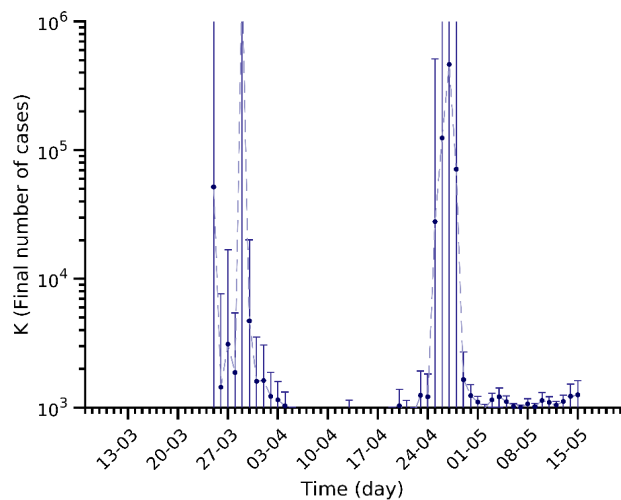
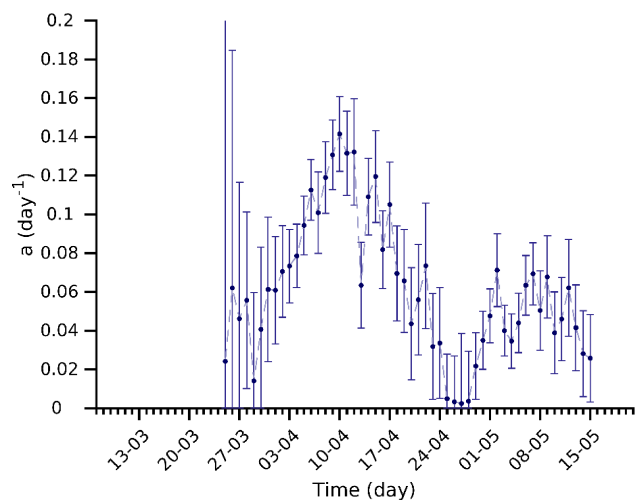
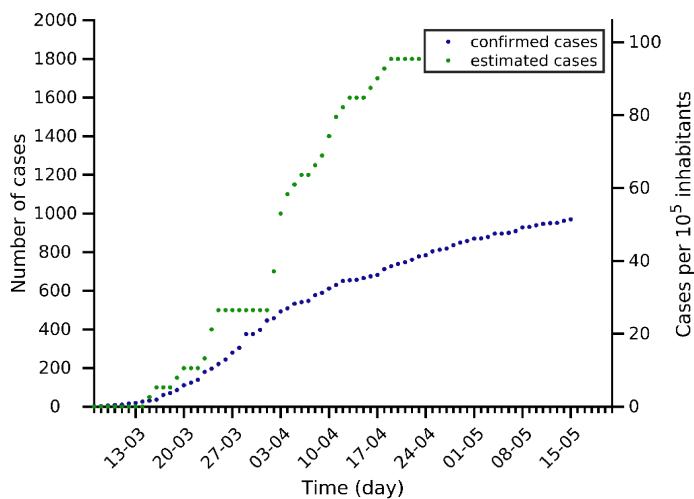
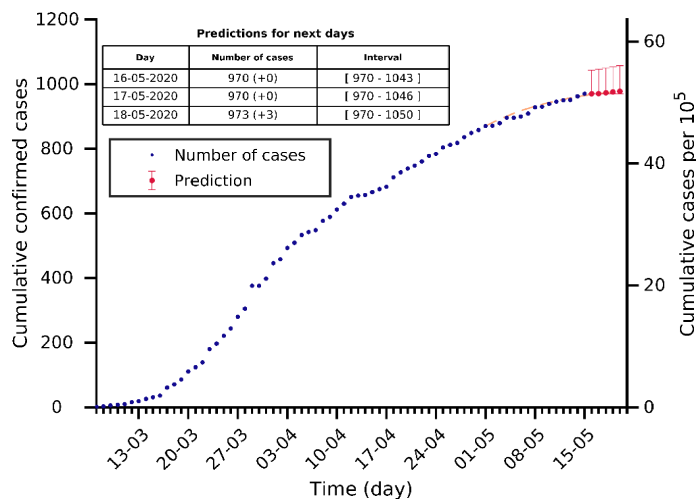
Slovakia 15-05-2020. Population: 5.5M. Current cumulated incidence: 27/10⁵



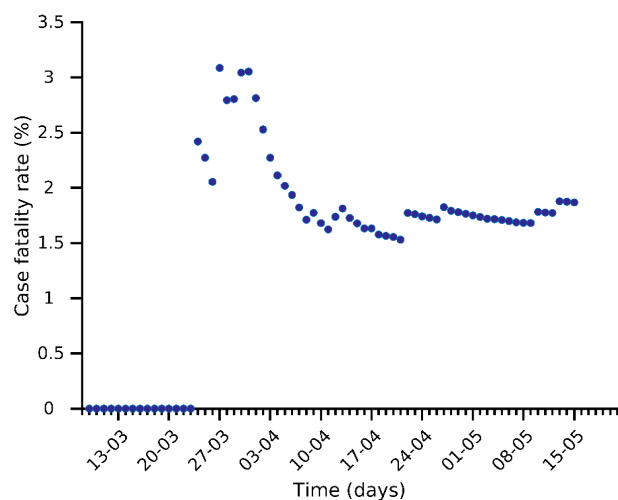
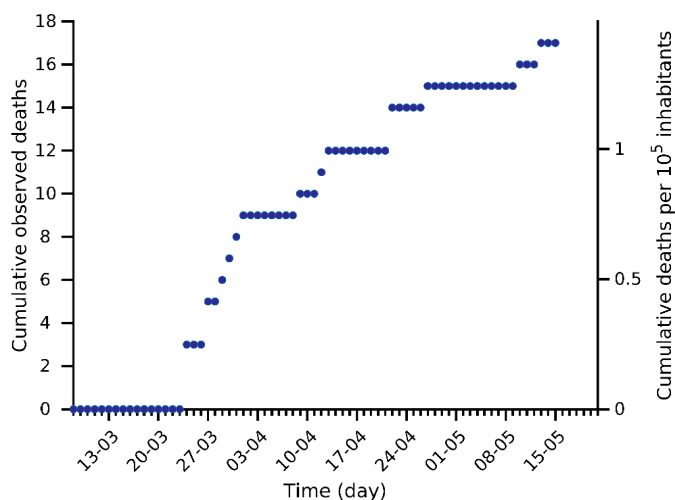
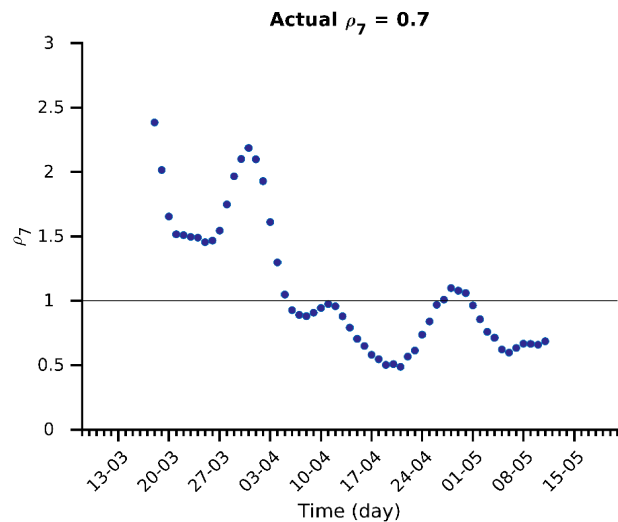
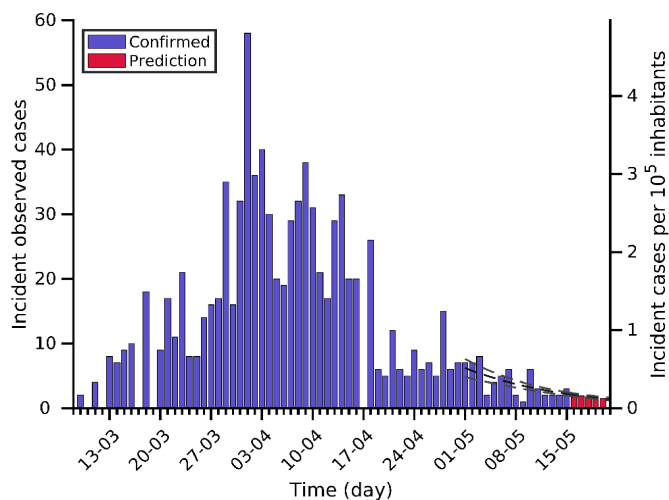
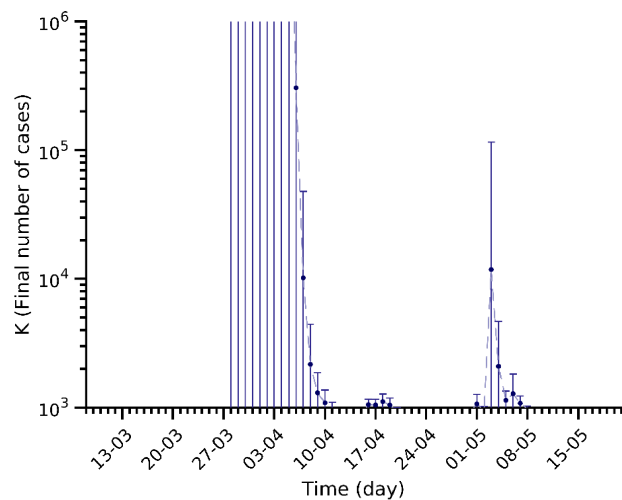
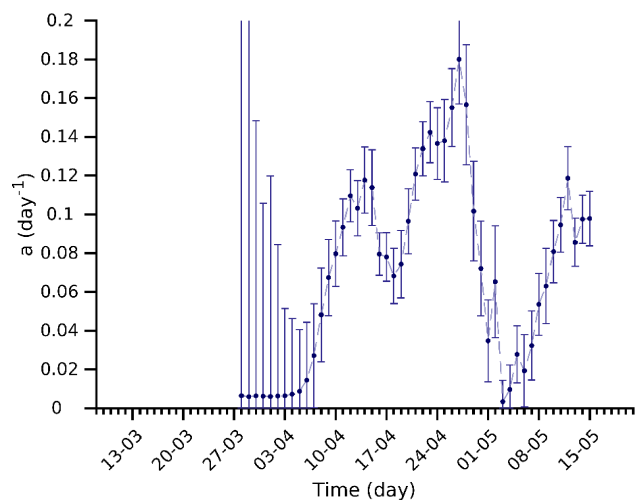
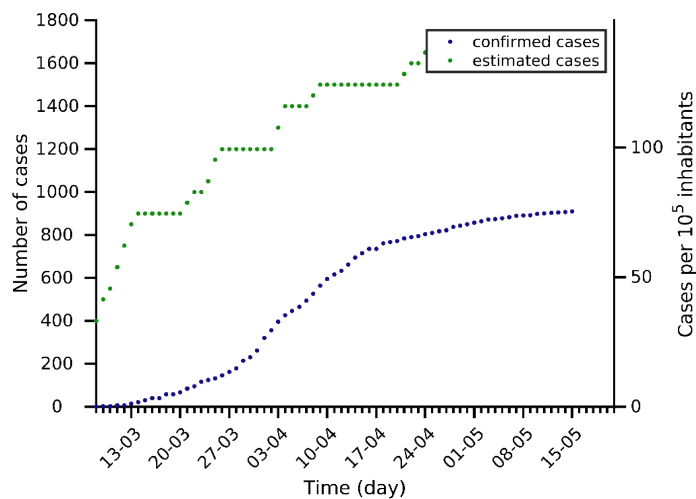
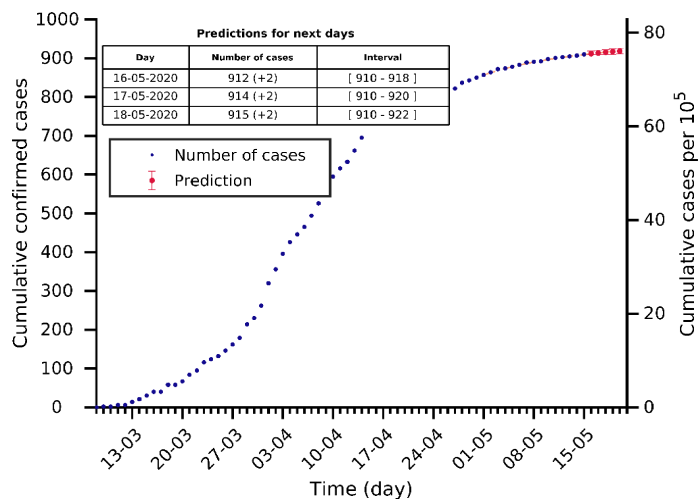
Slovenia 15-05-2020. Population: 2.1M. Current cumulated incidence: 70/10⁵



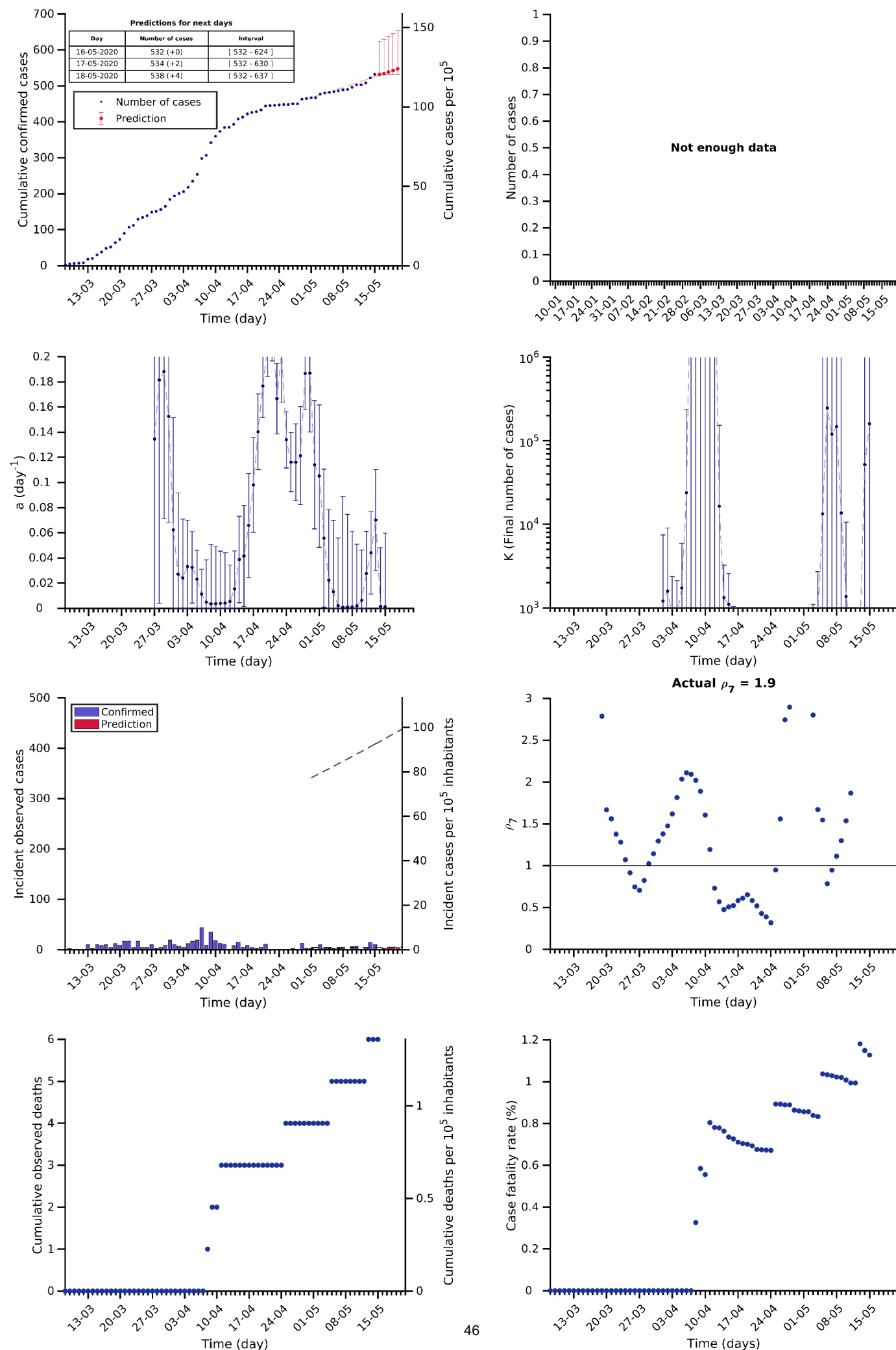
Latvia 15-05-2020. Population: 1.9M. Current cumulated incidence: 51/10⁵



Cyprus 15-05-2020. Population: 1.2M. Current cumulated incidence: 75/10⁵



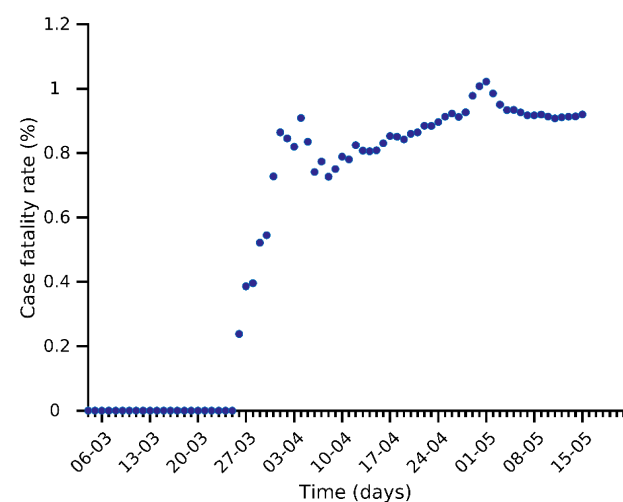
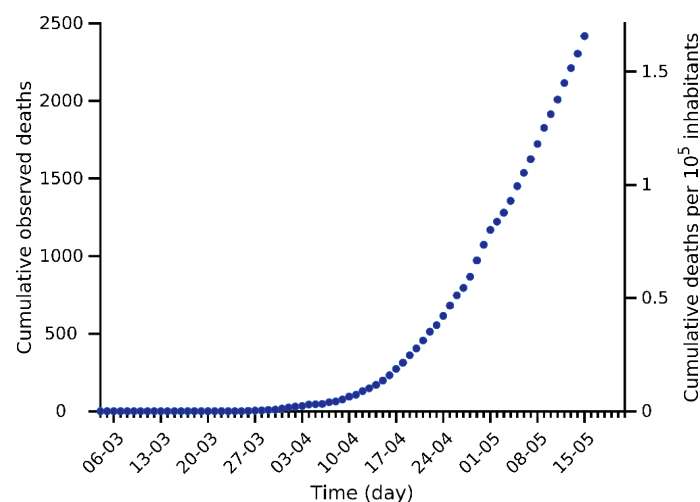
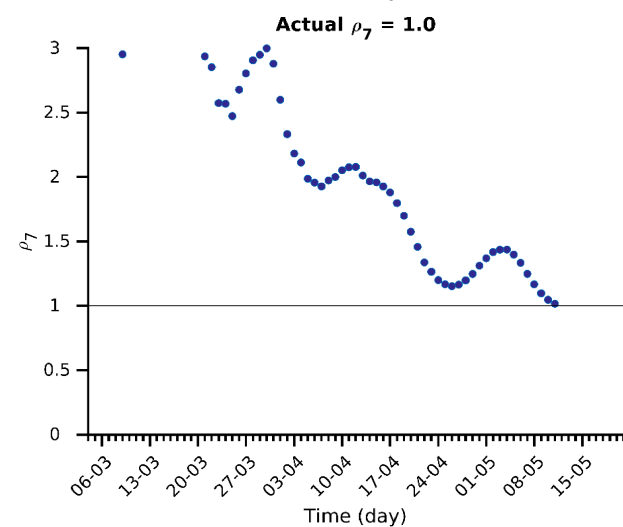
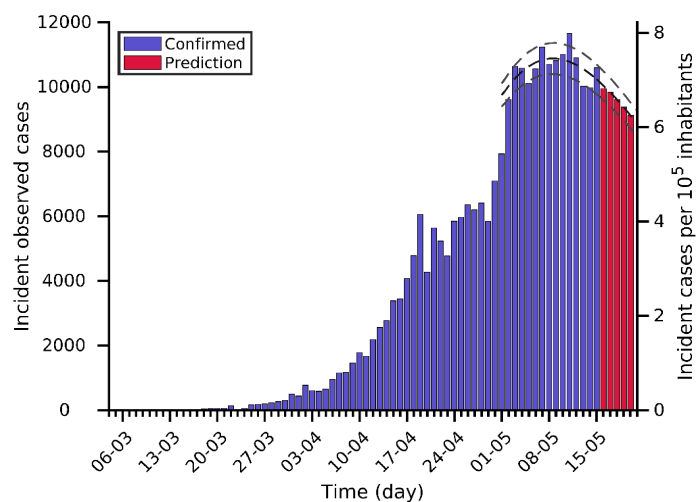
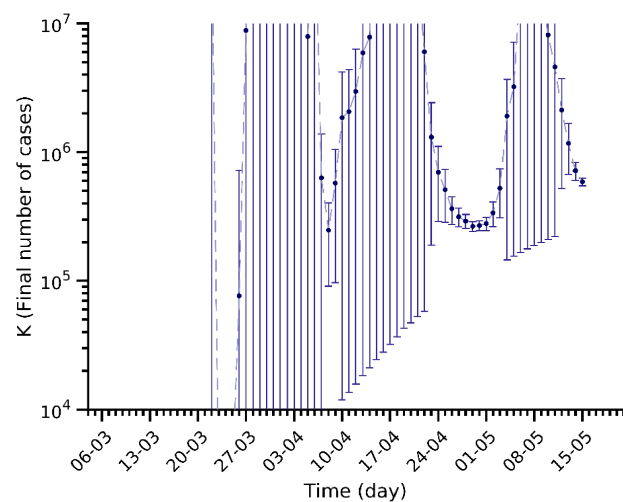
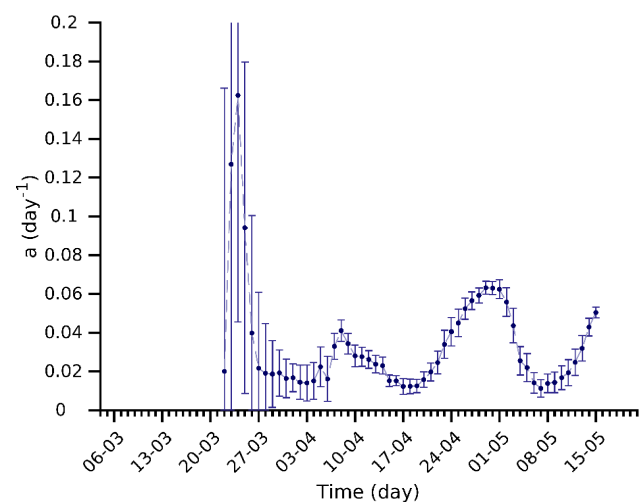
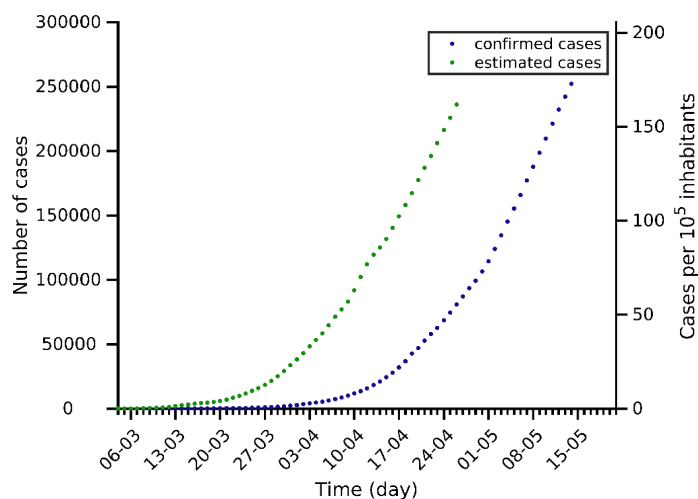
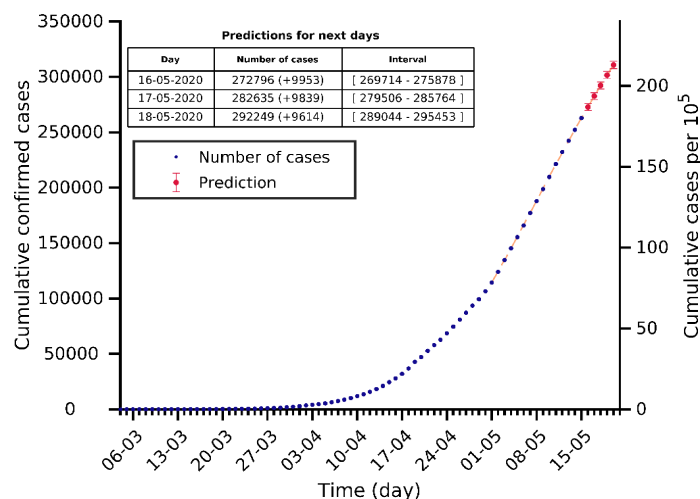
Malta 15-05-2020. Population: 0.4M. Current cumulated incidence: 120/10⁵



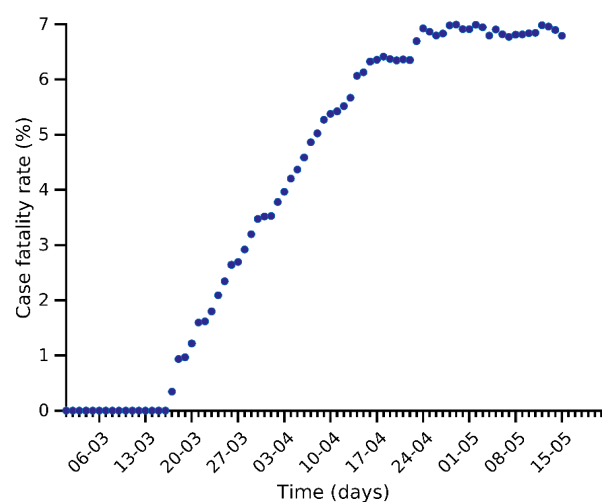
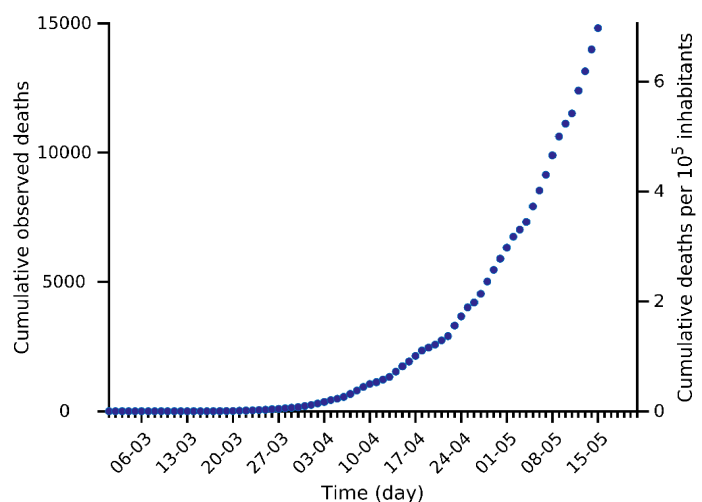
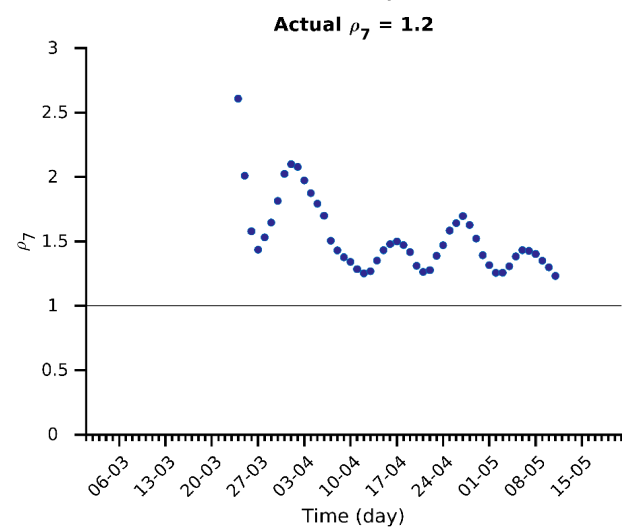
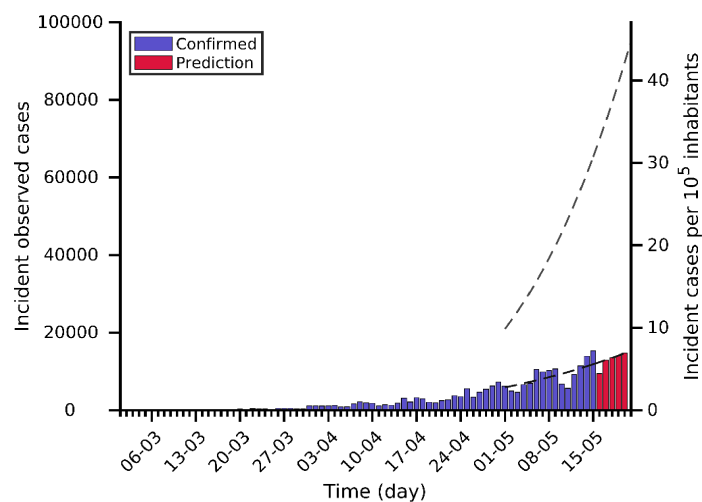
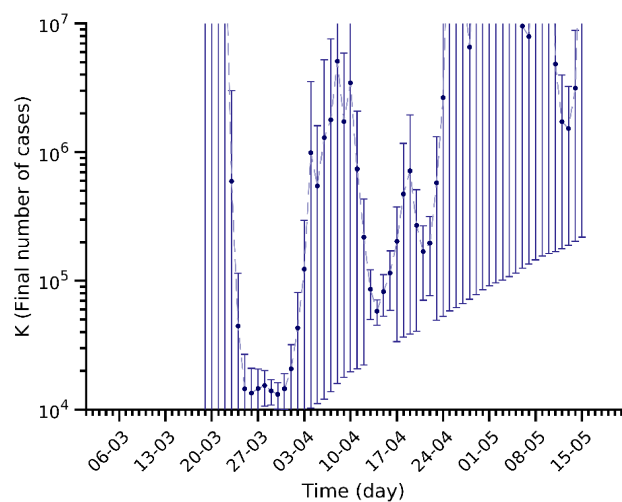
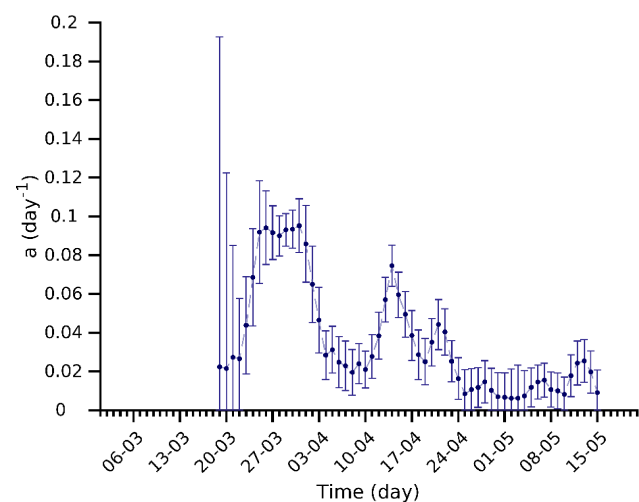
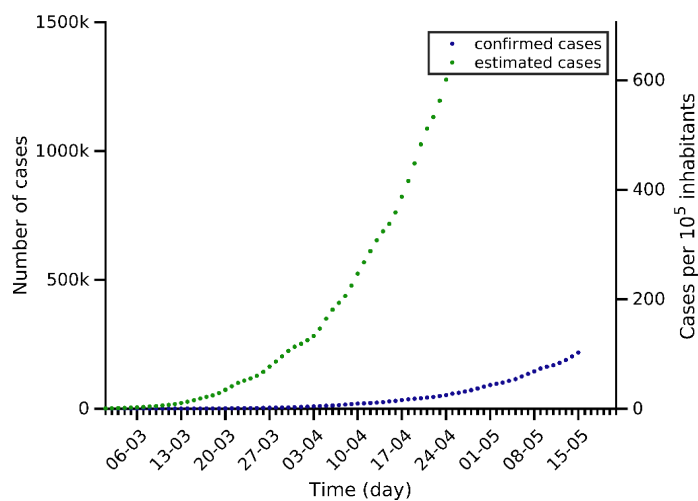
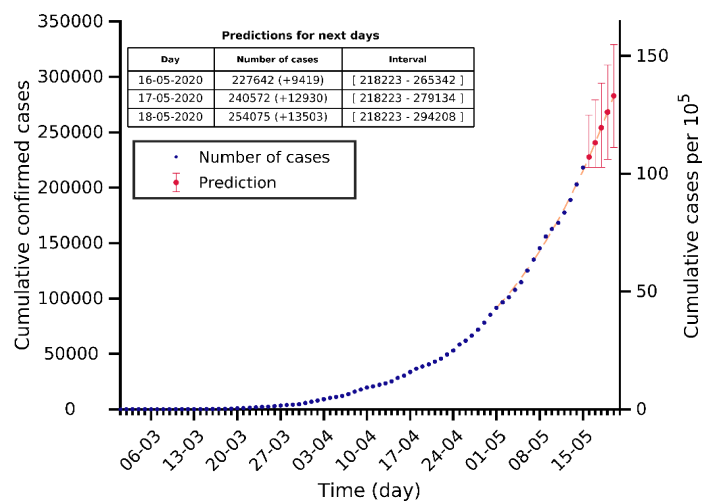
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

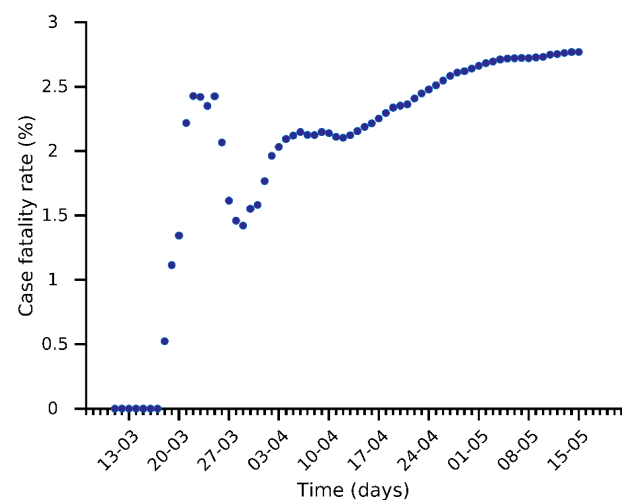
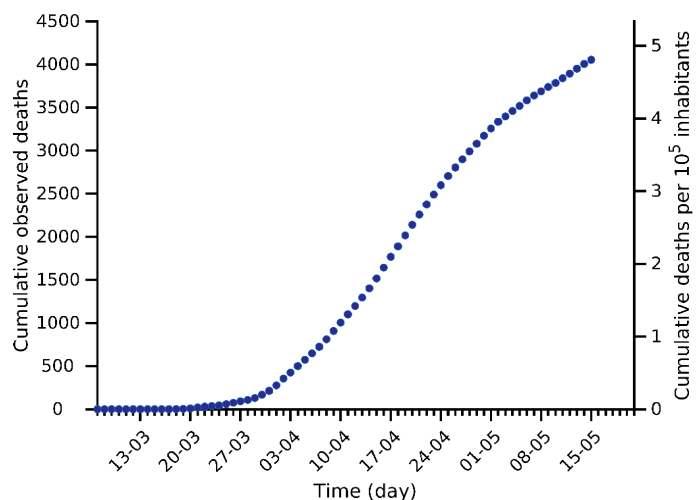
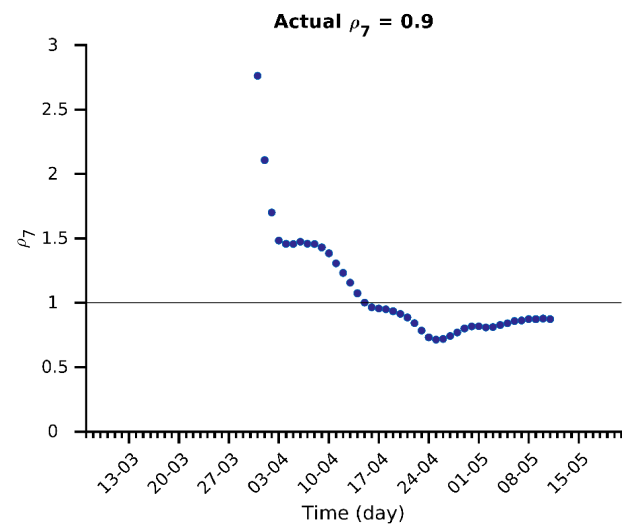
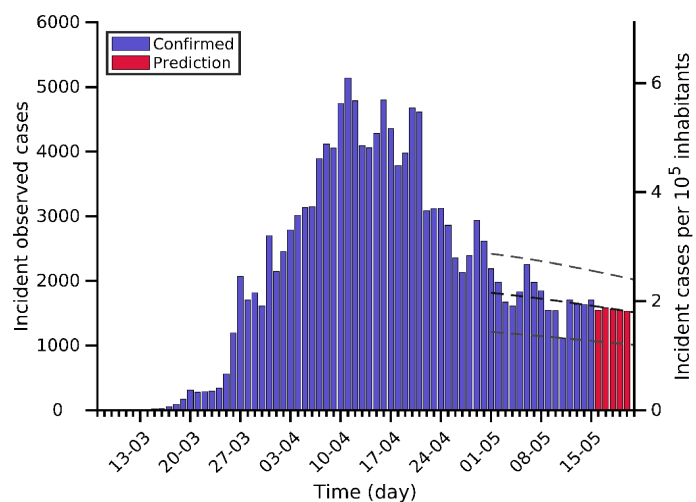
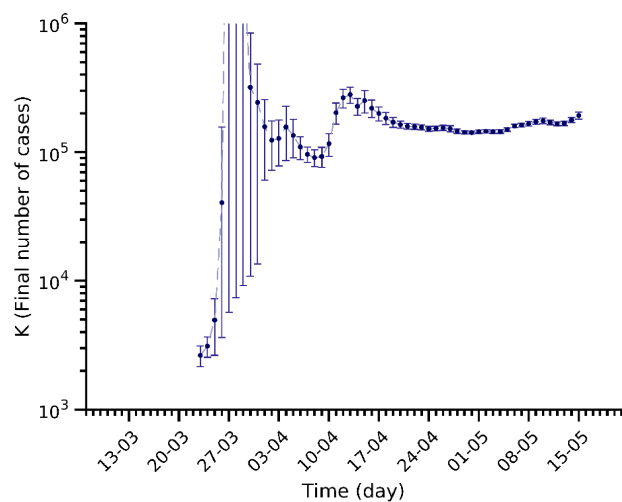
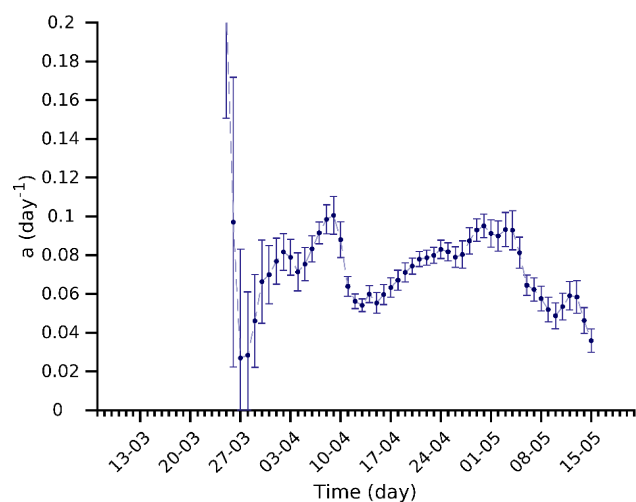
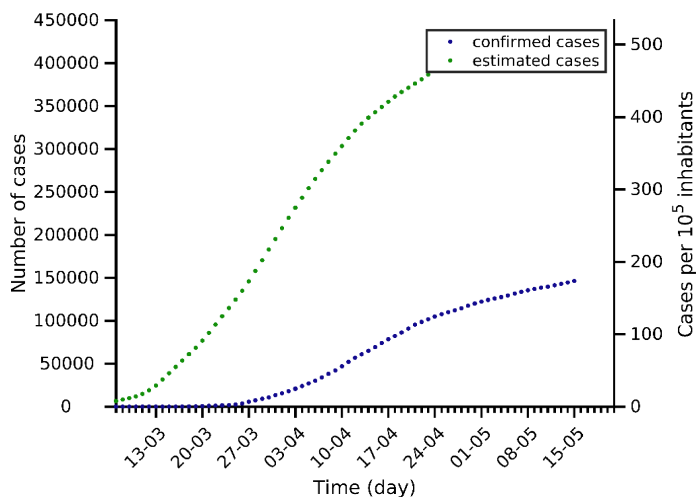
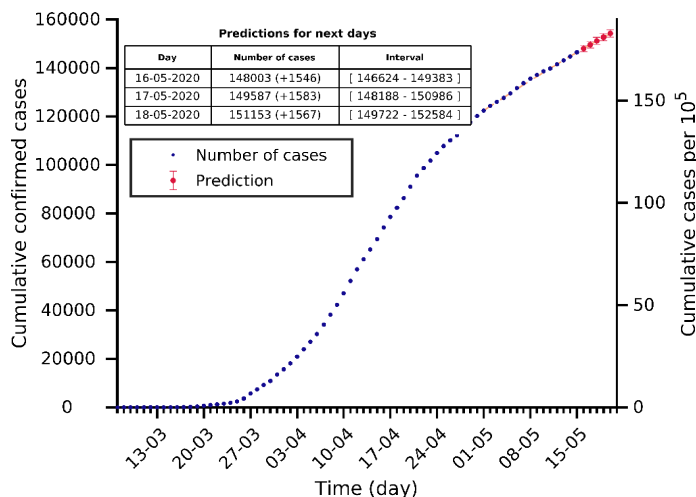
Russia 15-05-2020. Population: 145.9M. Current cumulated incidence: 180/10⁵



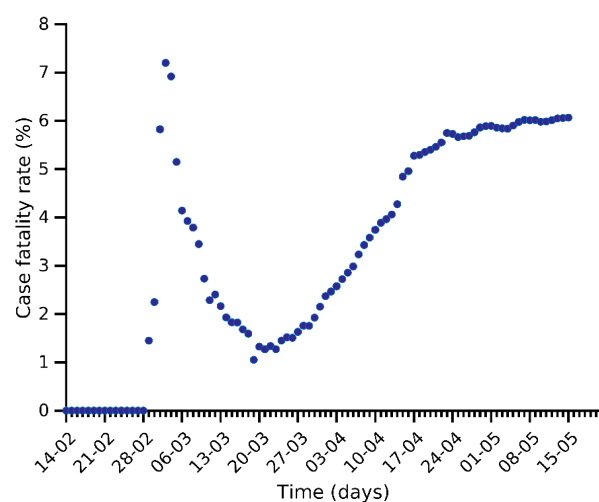
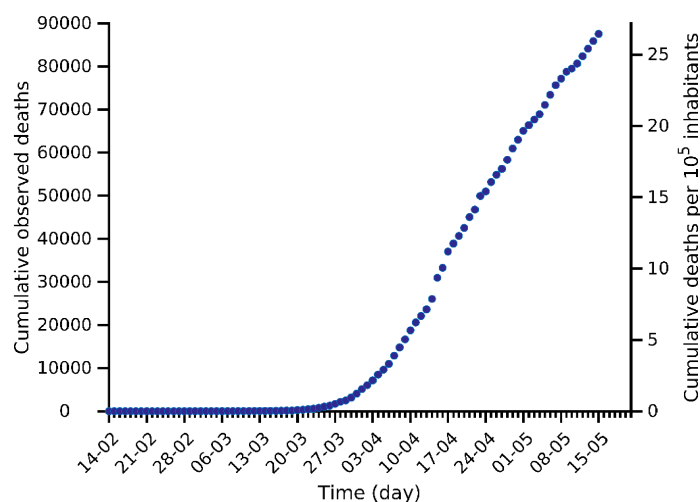
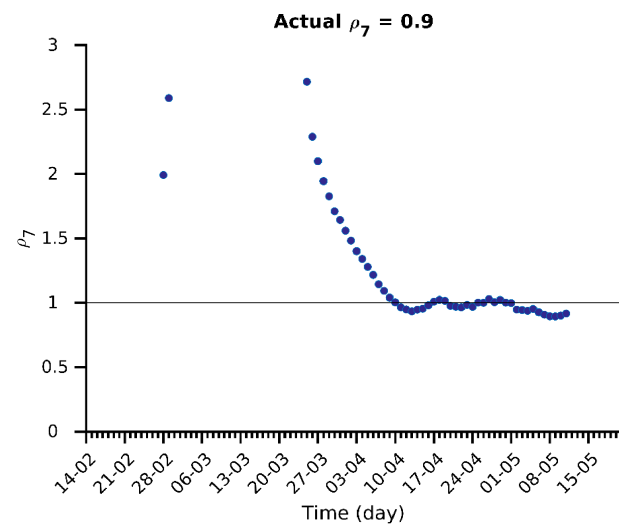
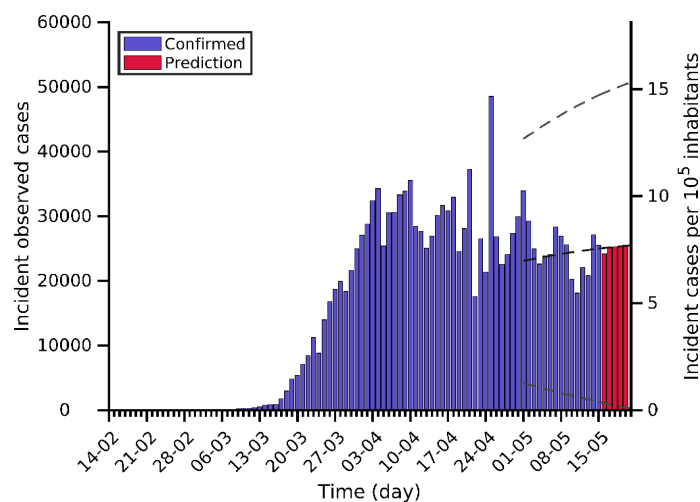
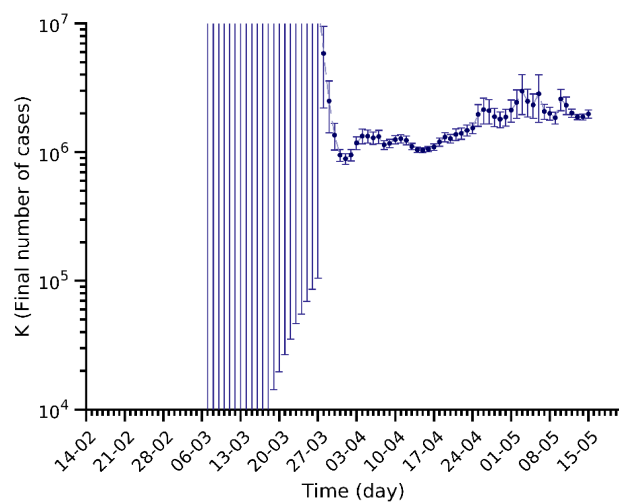
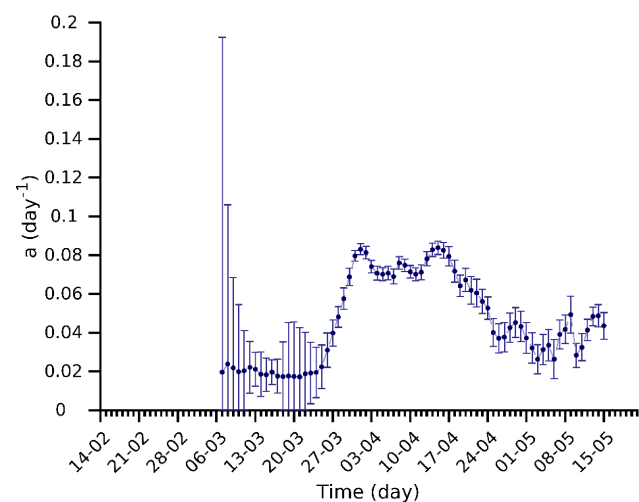
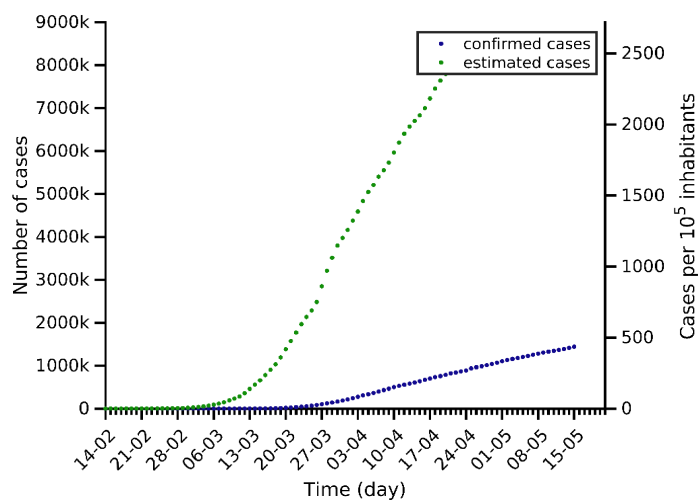
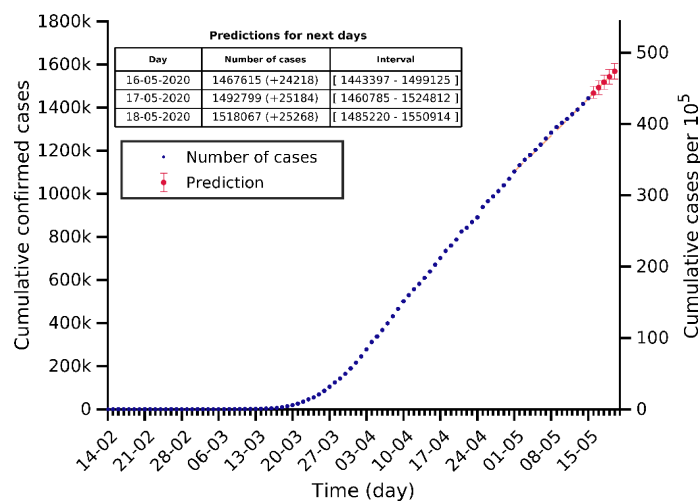
Brazil 15-05-2020. Population: 212.6M. Current cumulated incidence: 103/10⁵



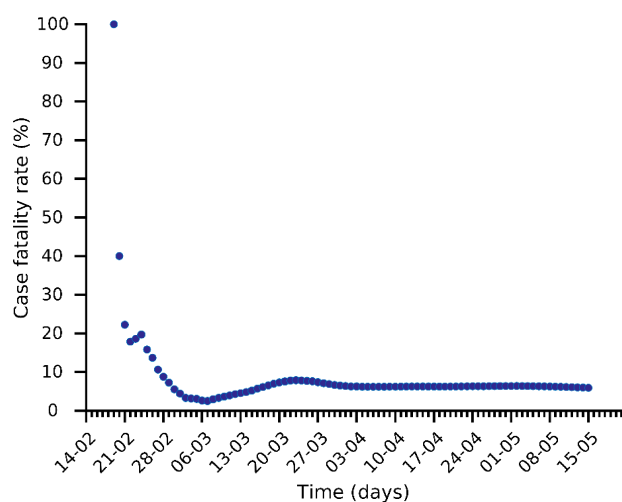
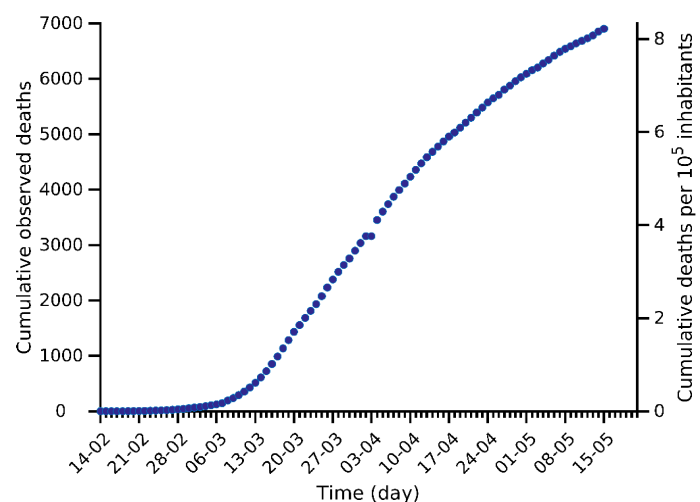
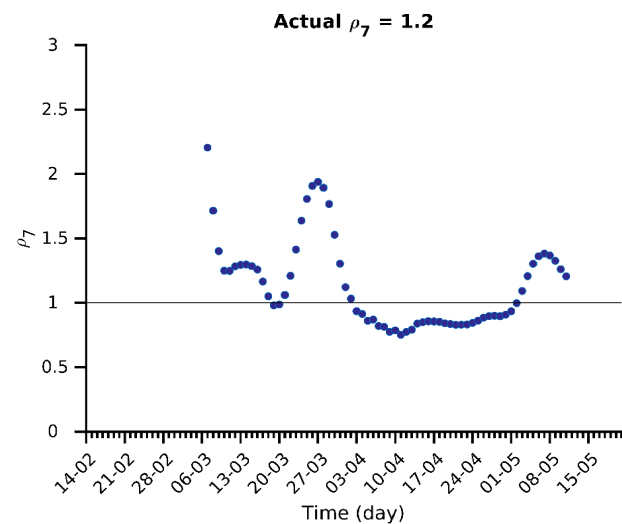
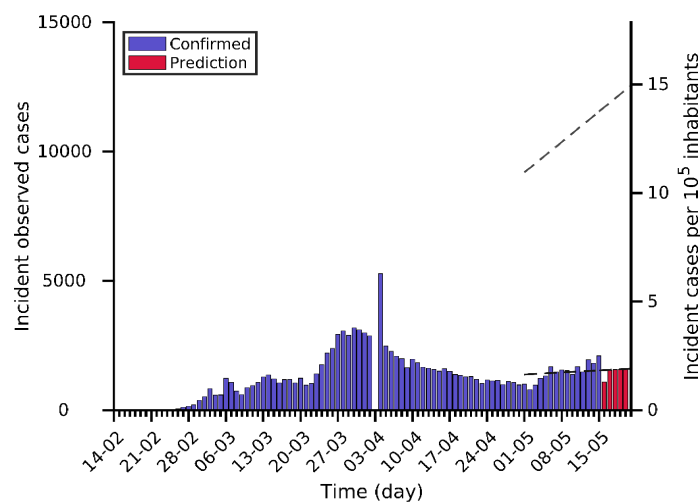
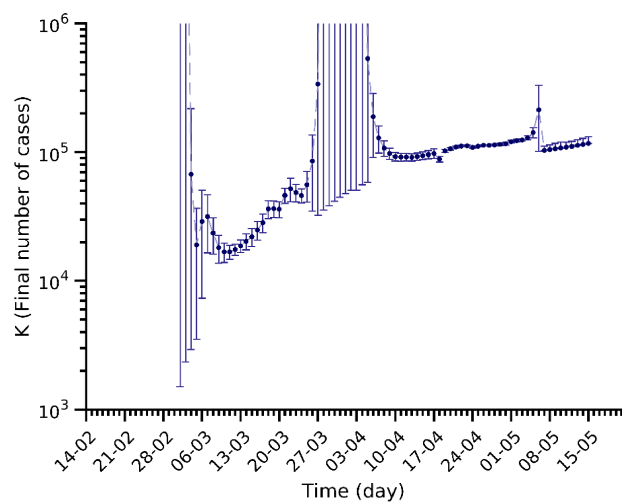
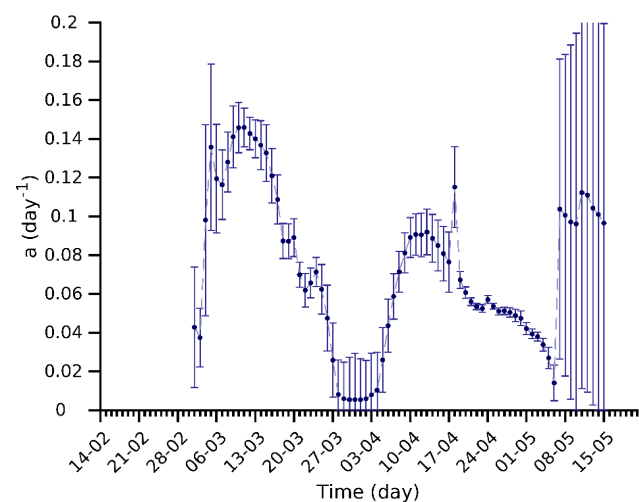
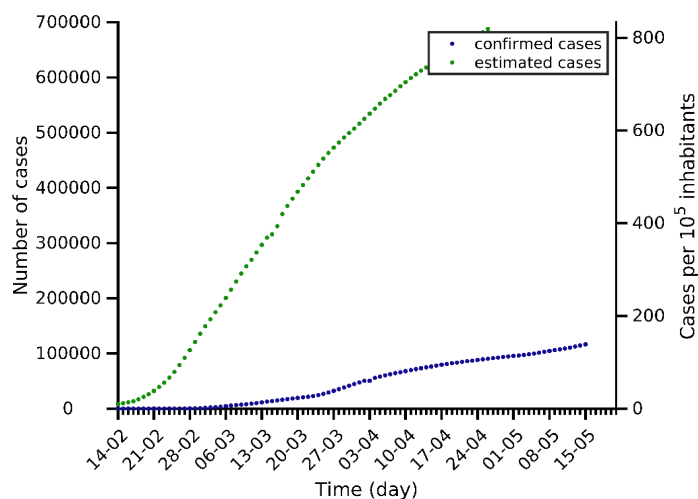
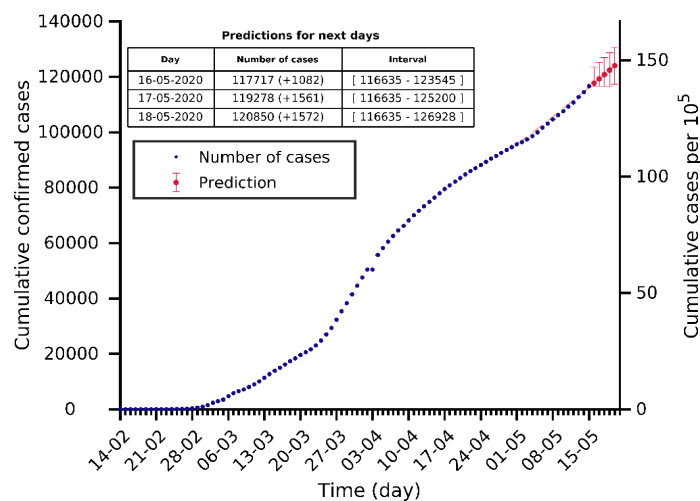
Turkey 15-05-2020. Population: 84.3M. Current cumulated incidence: 174/10⁵



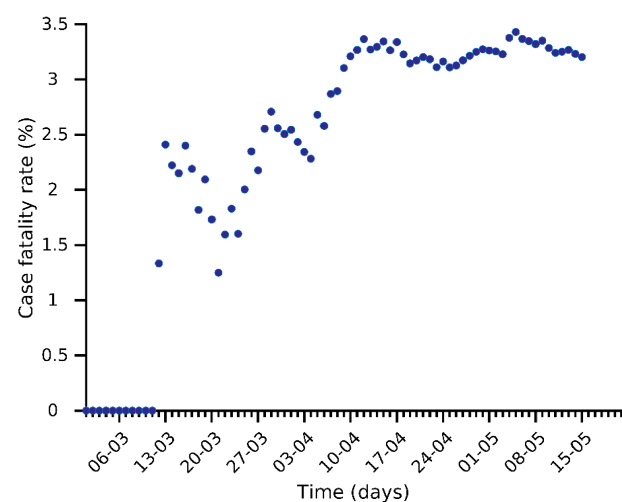
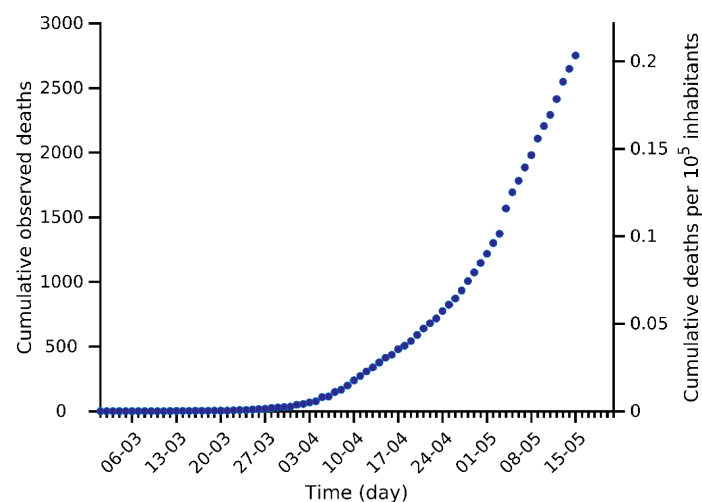
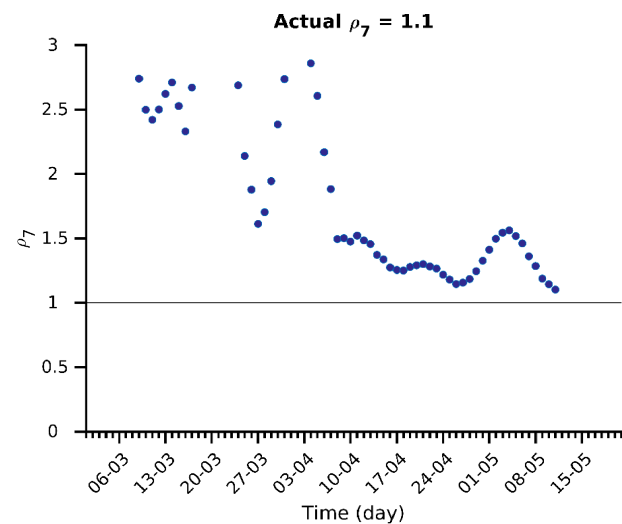
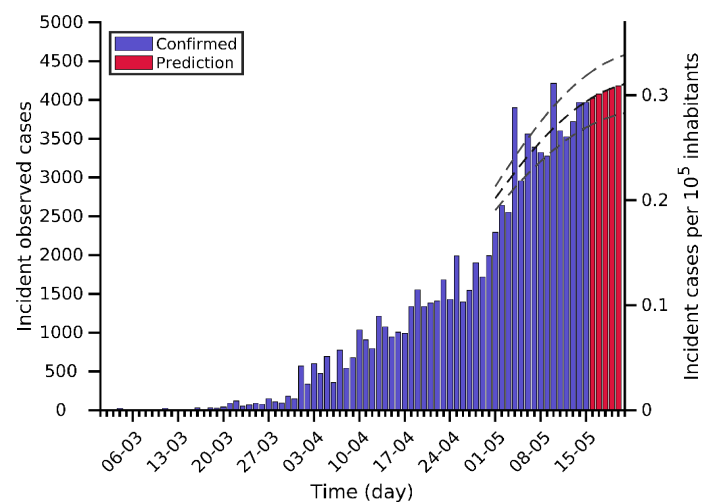
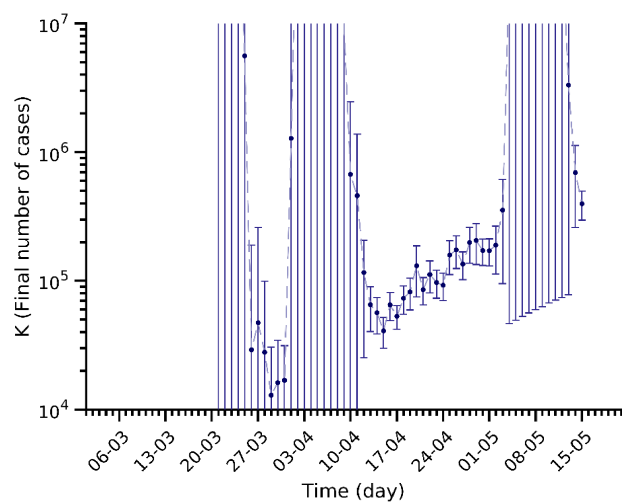
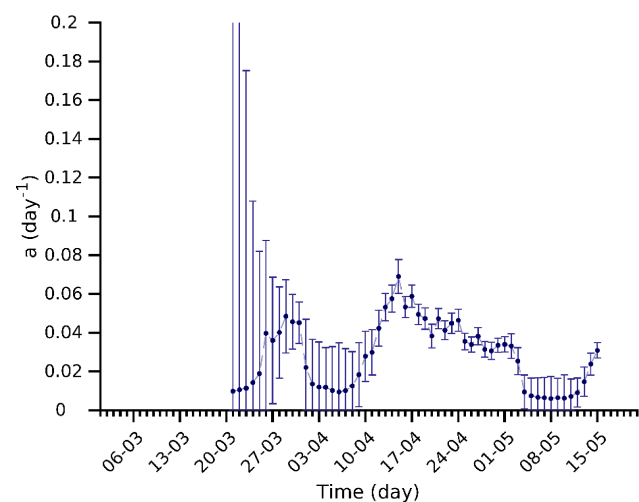
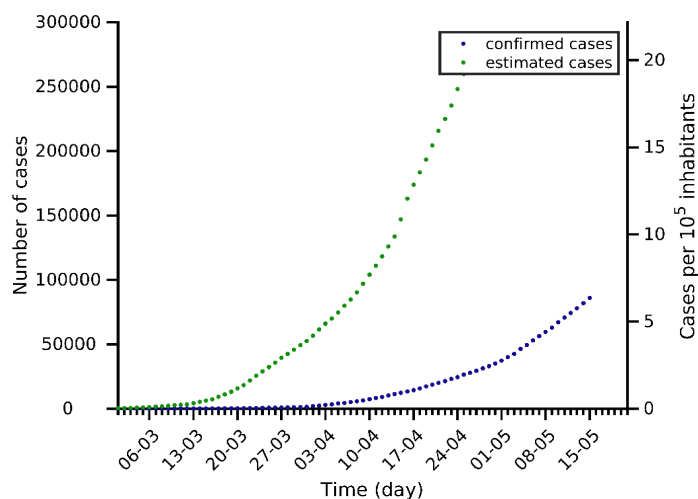
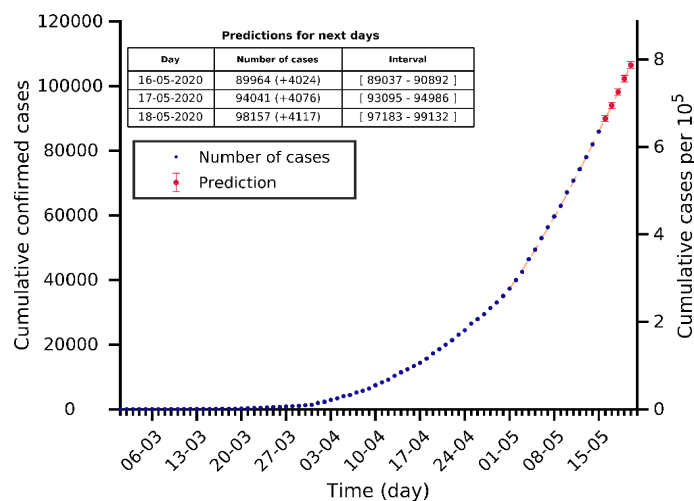
USA 15-05-2020. Population: 331.0M. Current cumulated incidence: 436/10⁵



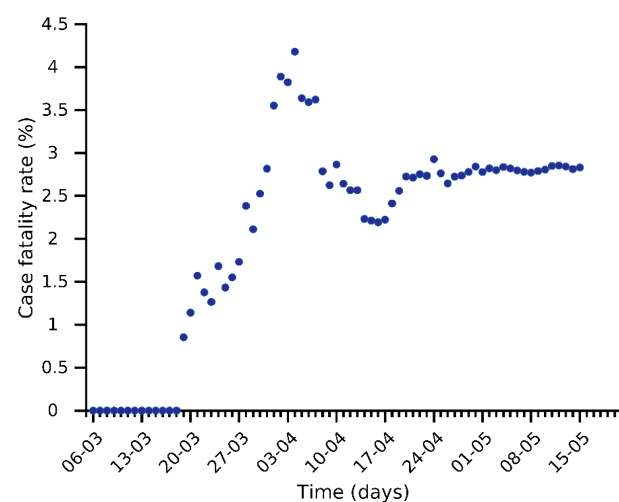
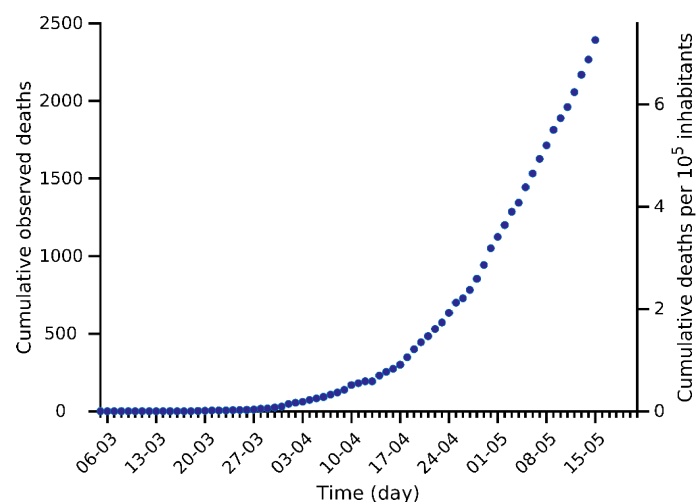
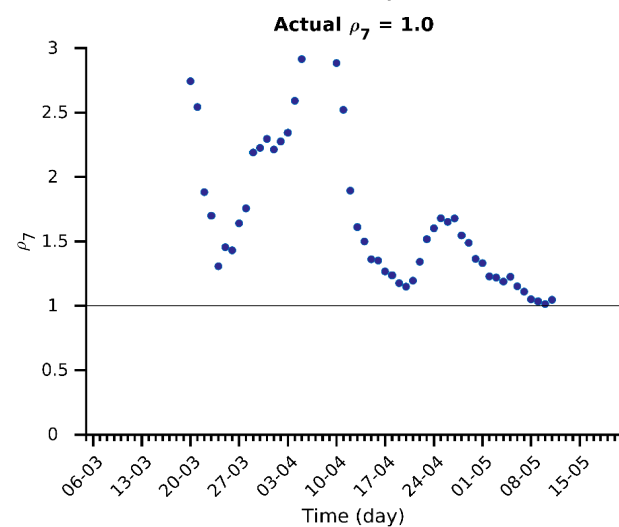
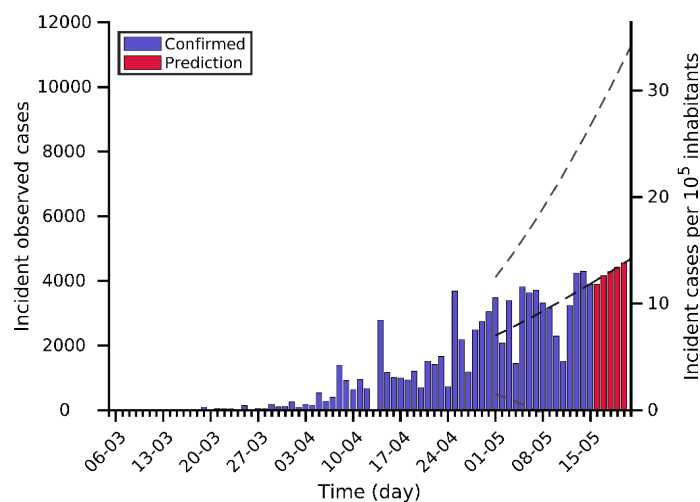
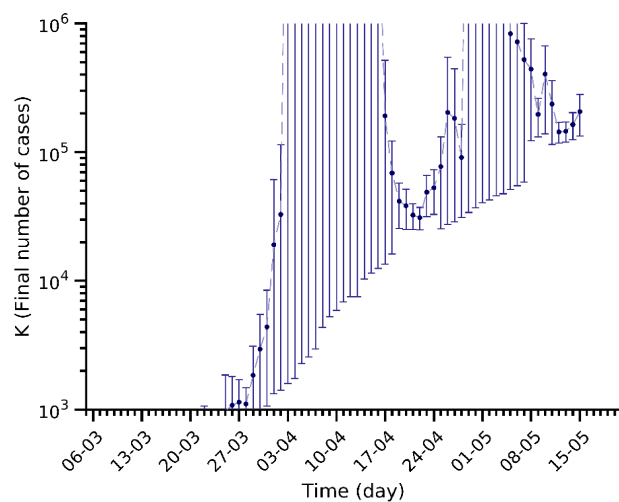
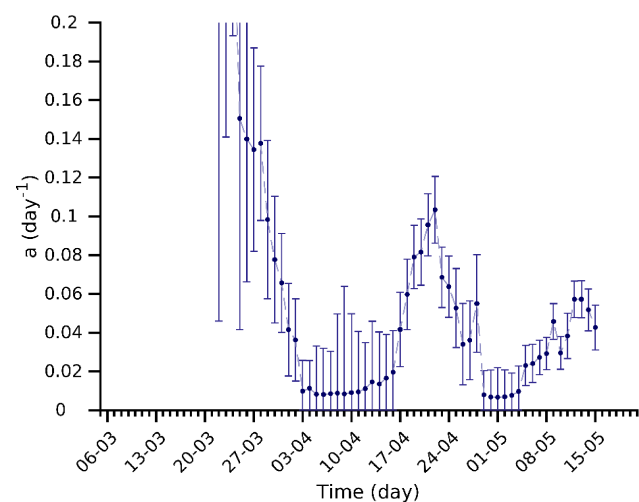
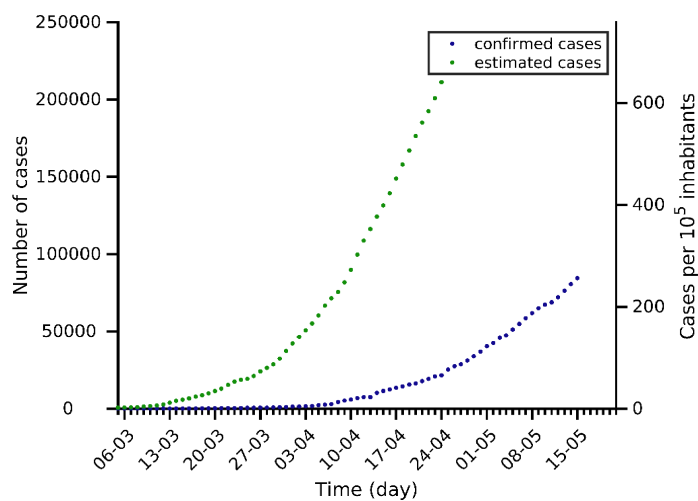
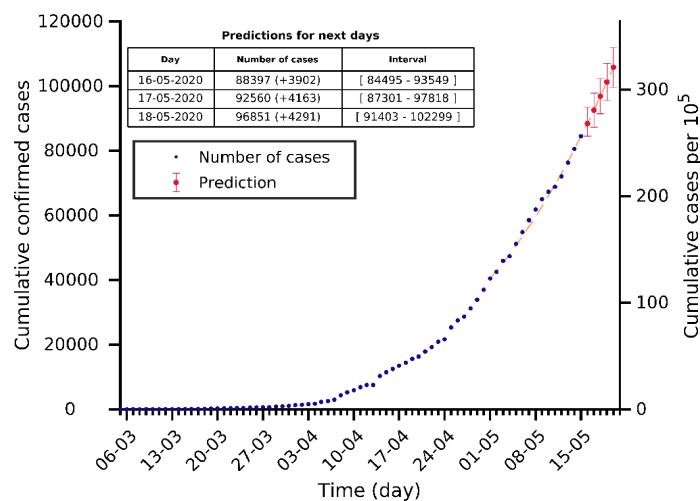
Iran 15-05-2020. Population: 84.0M. Current cumulated incidence: 139/10⁵



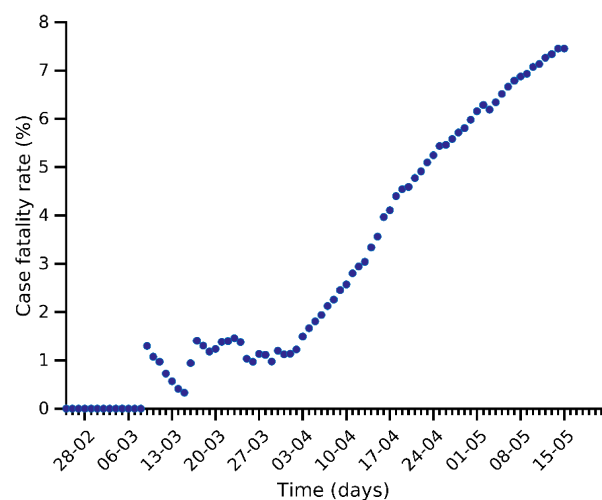
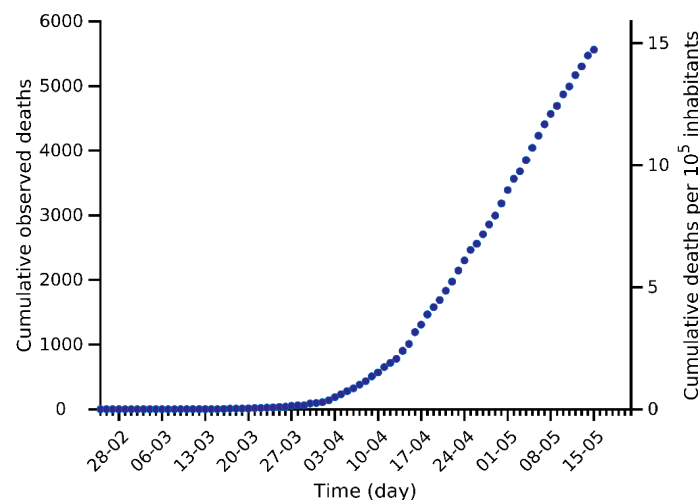
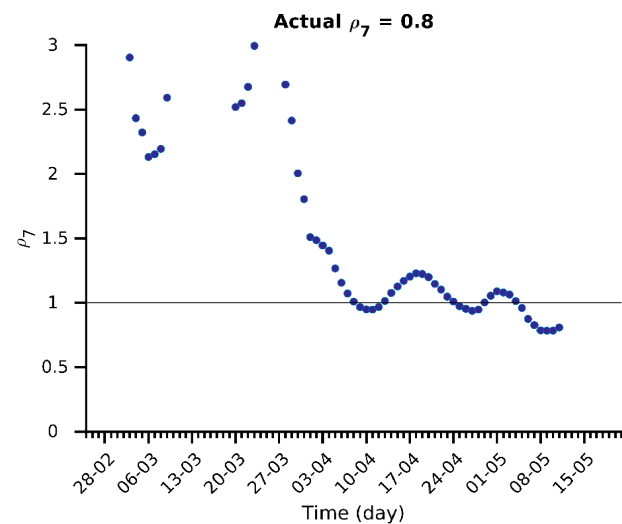
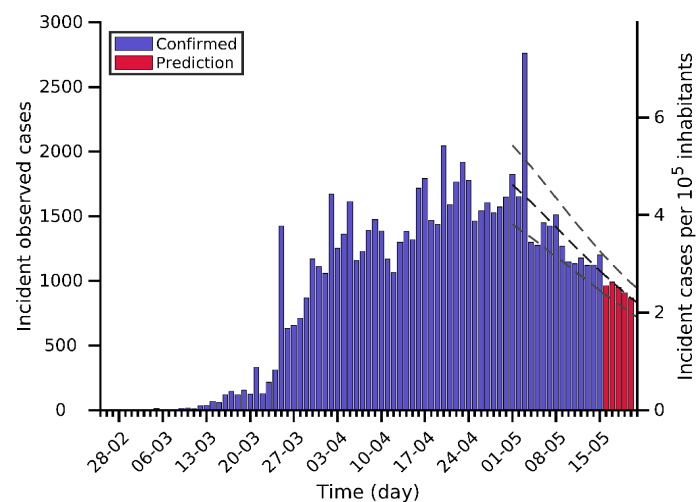
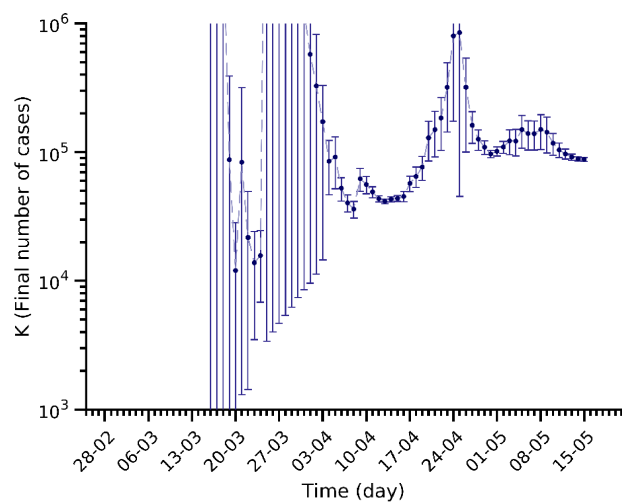
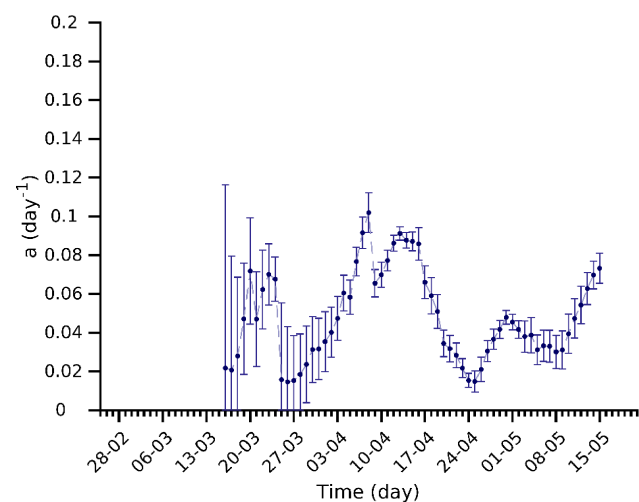
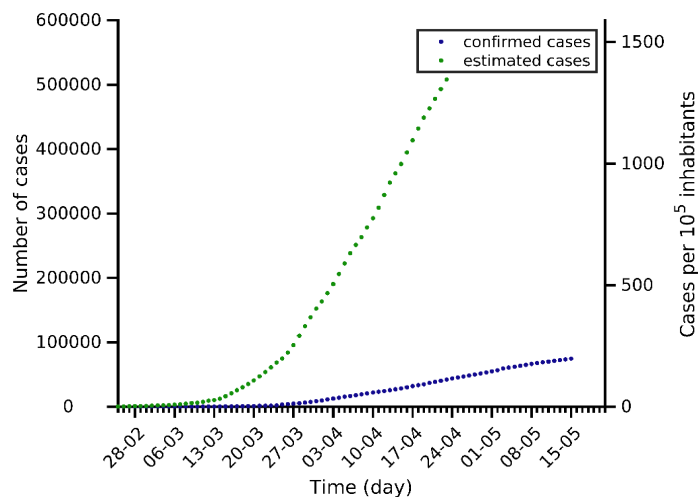
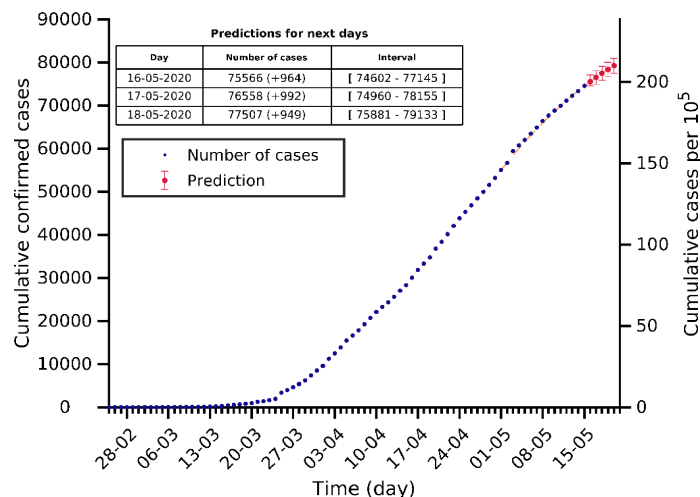
India 15-05-2020. Population: 1353.0M. Current cumulated incidence: 6/10⁵



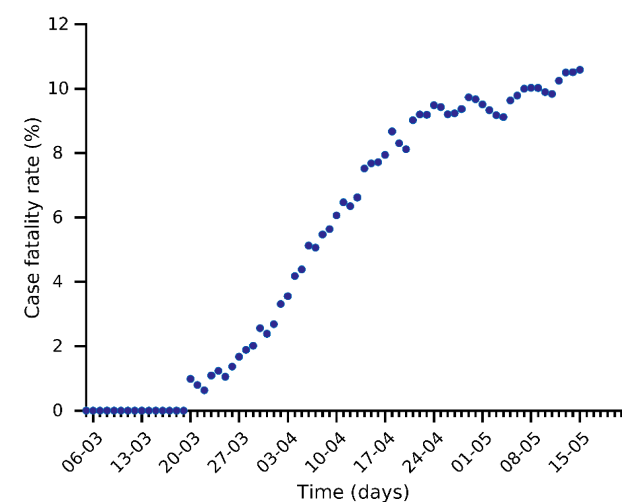
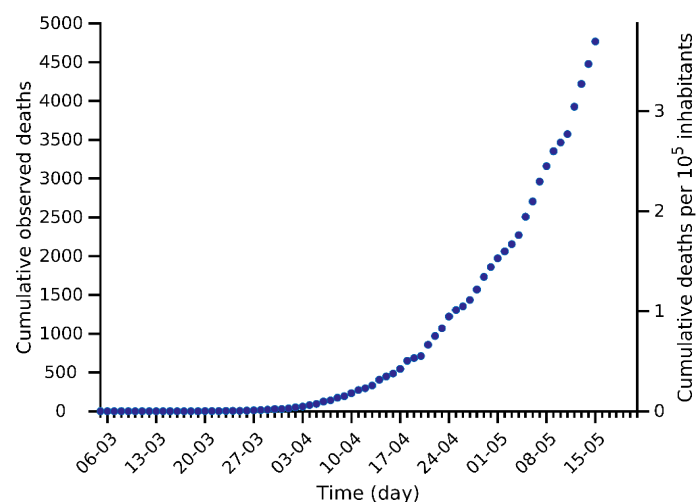
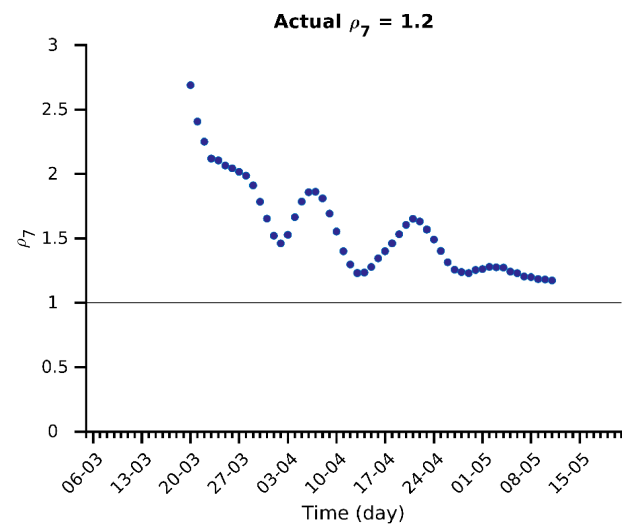
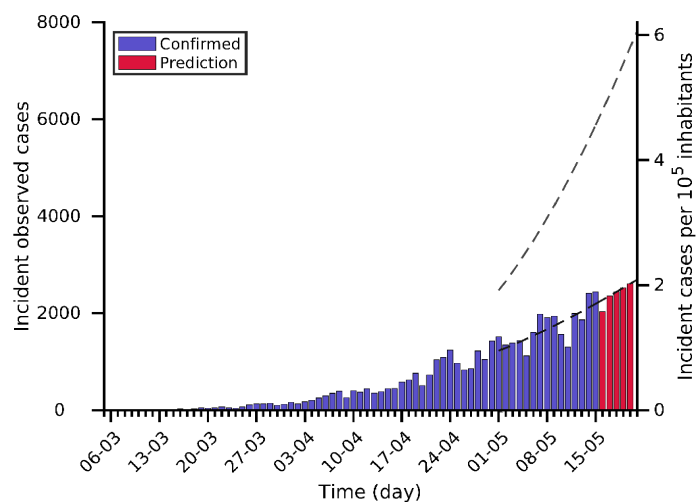
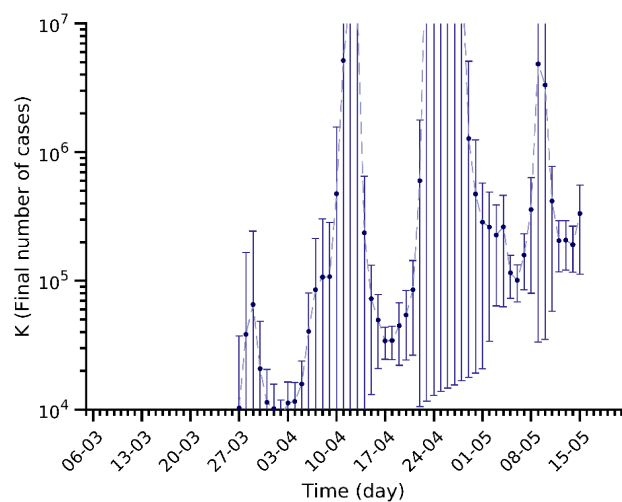
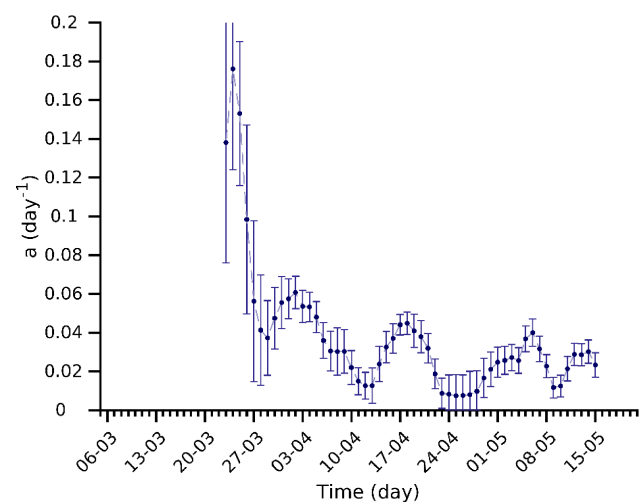
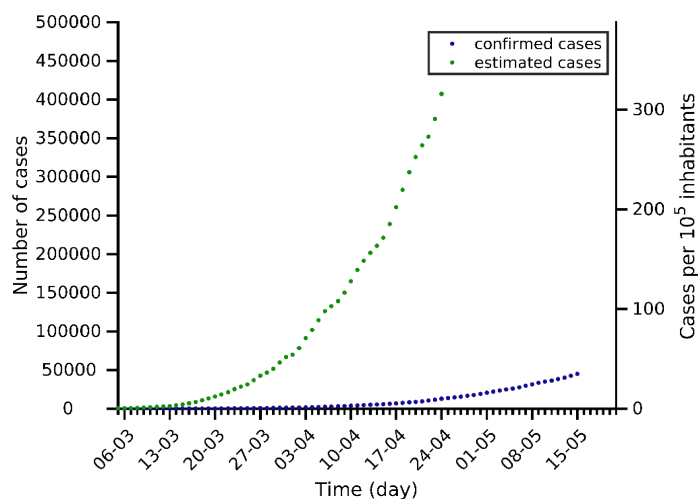
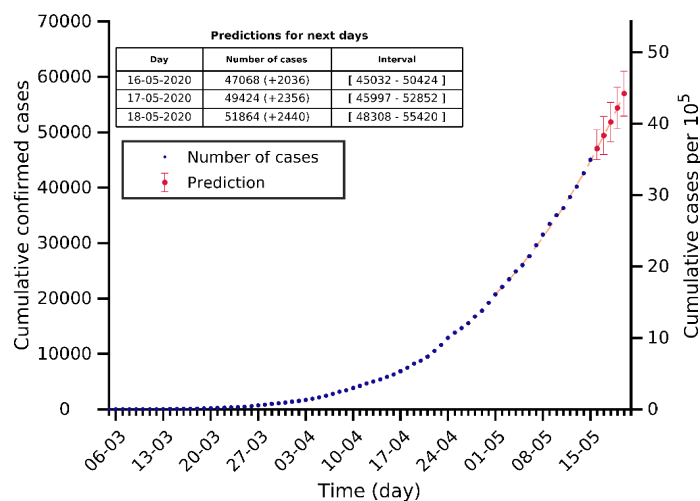
Peru 15-05-2020. Population: 33.0M. Current cumulated incidence: 256/10⁵



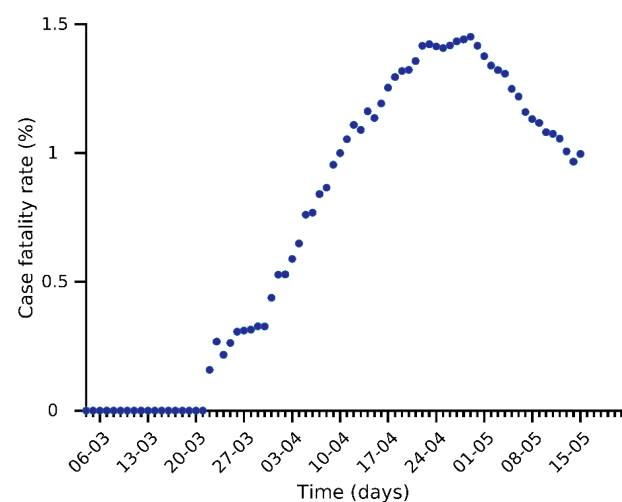
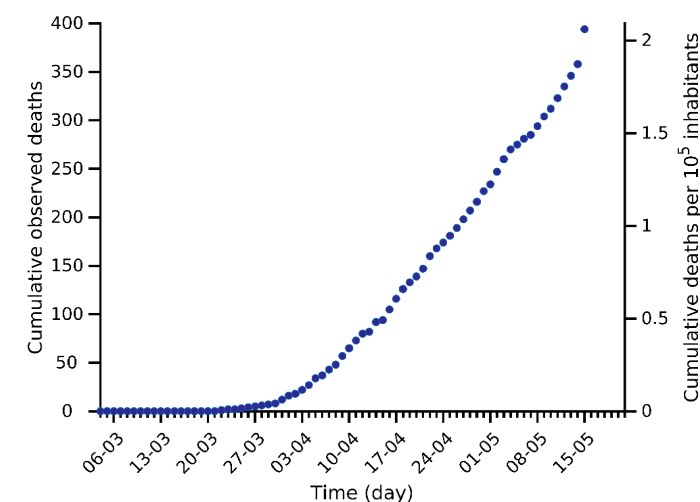
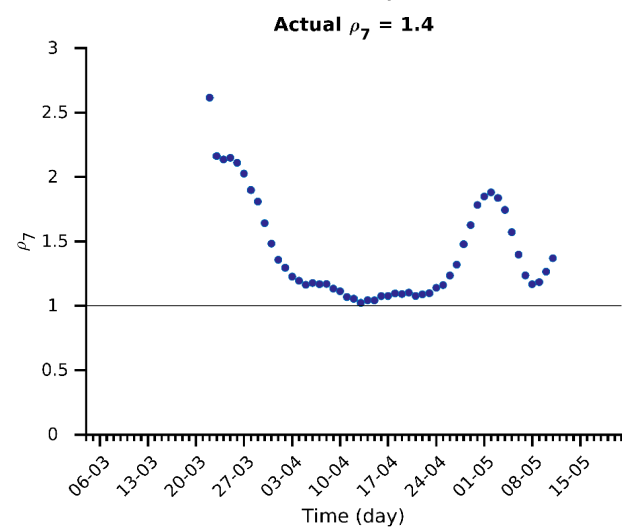
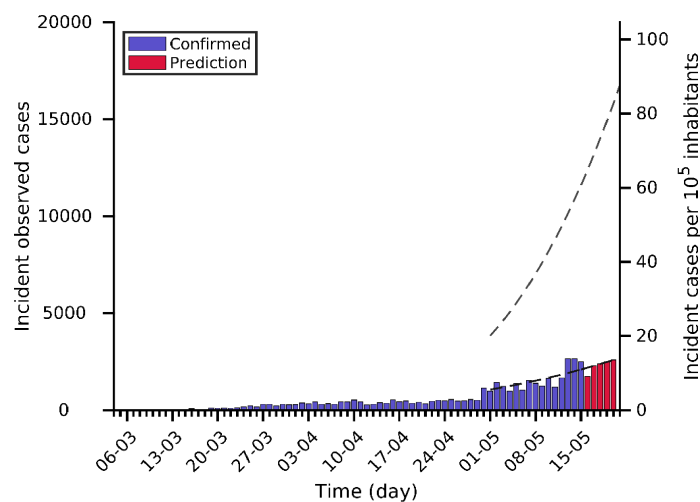
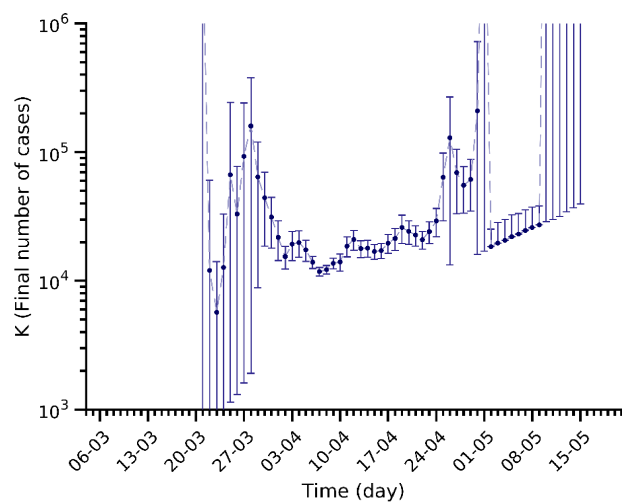
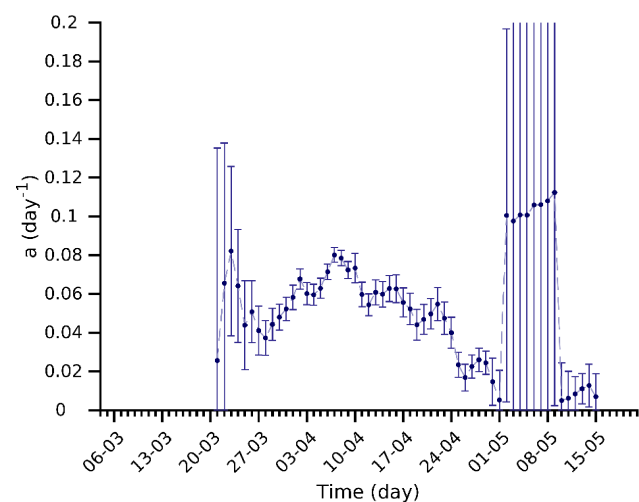
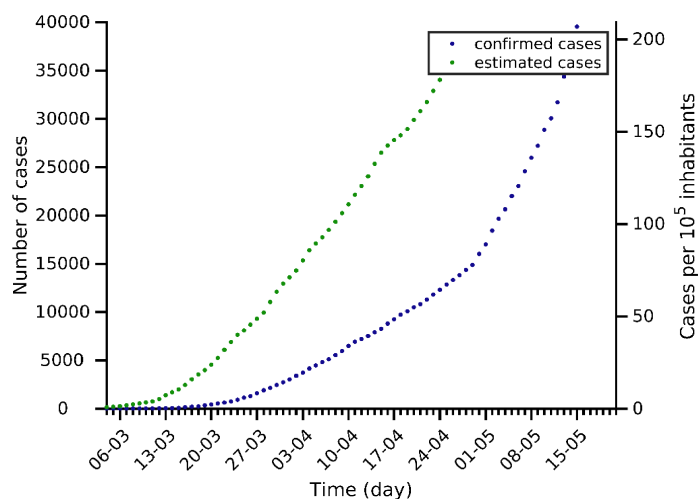
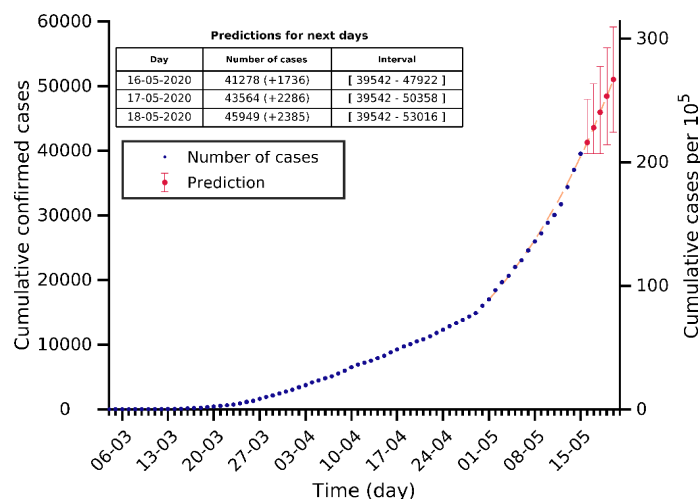
Canada 15-05-2020. Population: 37.7M. Current cumulated incidence: 198/10⁵



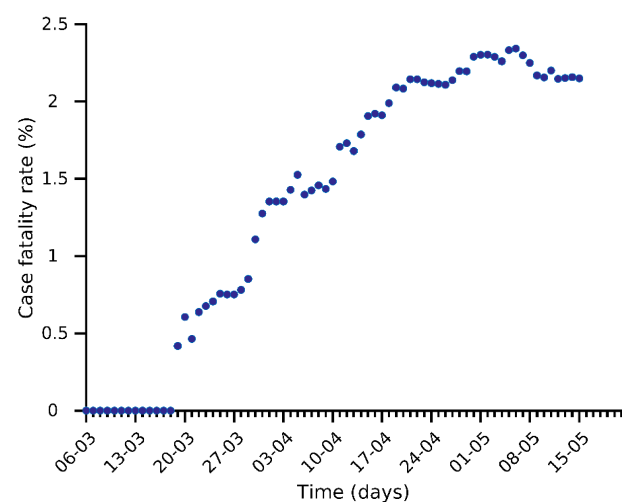
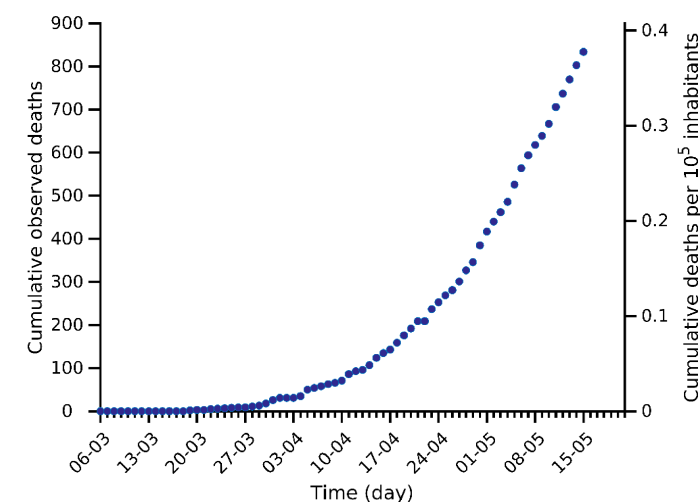
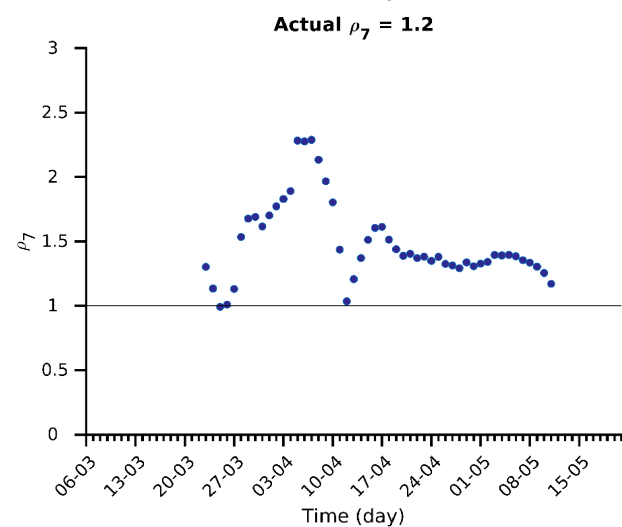
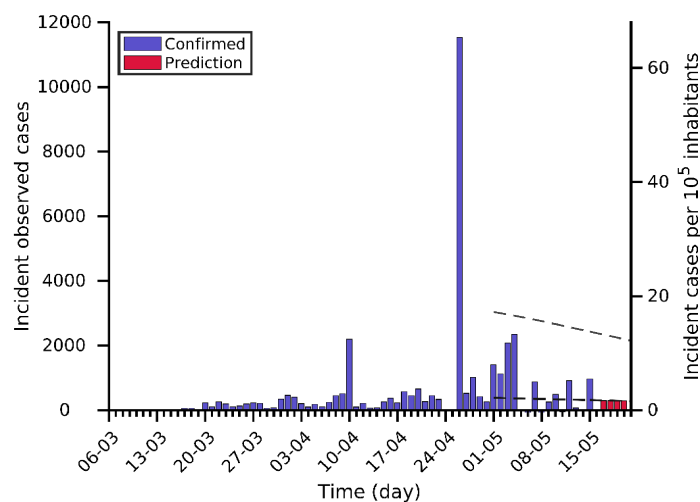
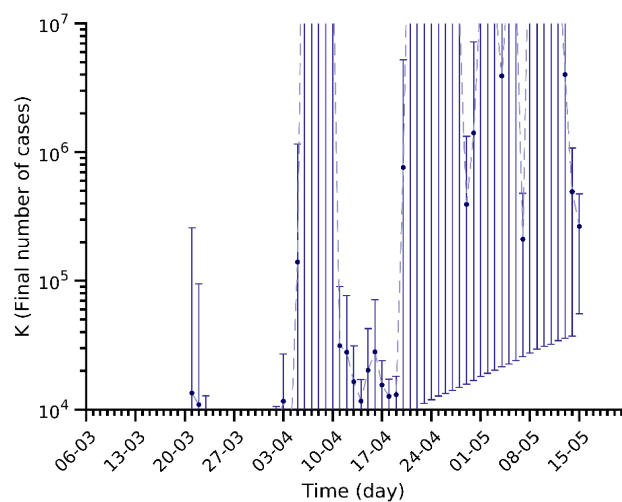
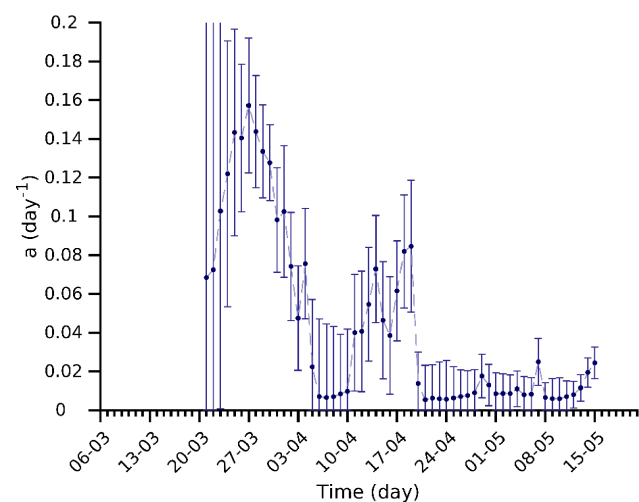
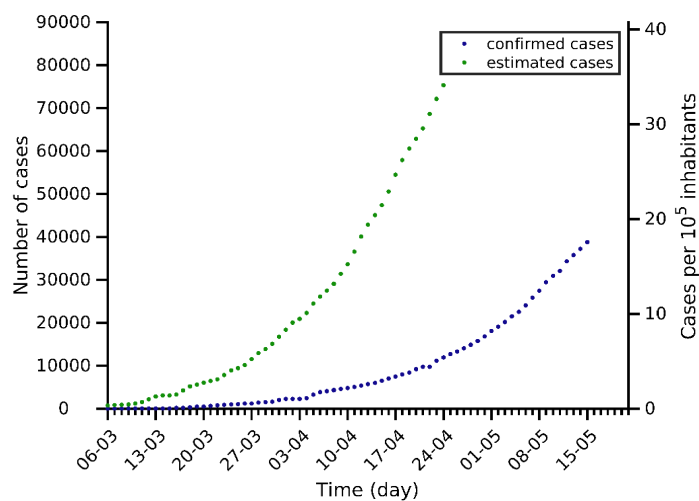
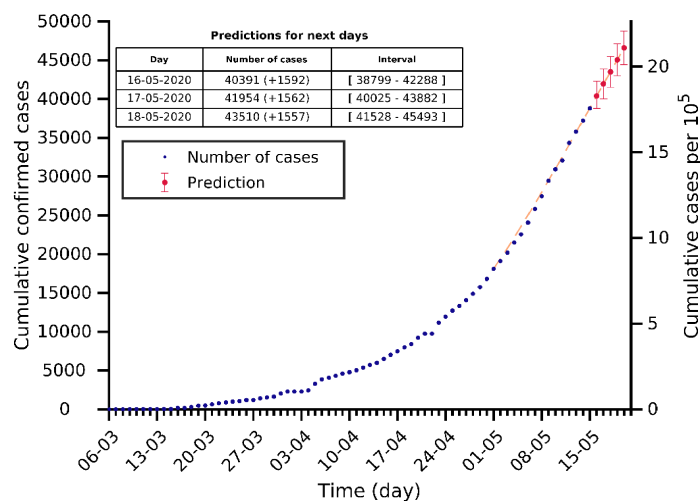
Mexico 15-05-2020. Population: 128.9M. Current cumulated incidence: 35/10⁵



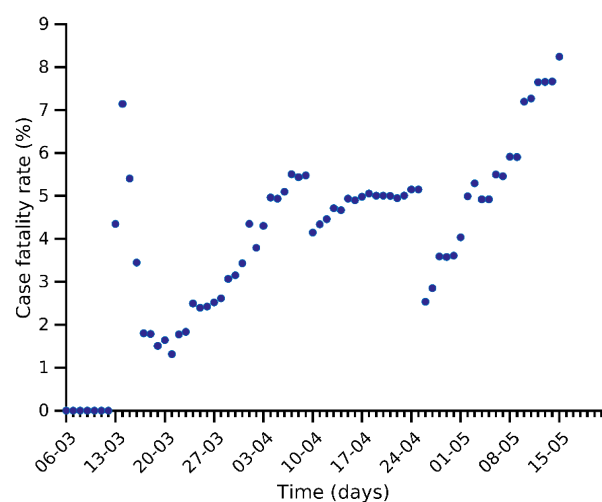
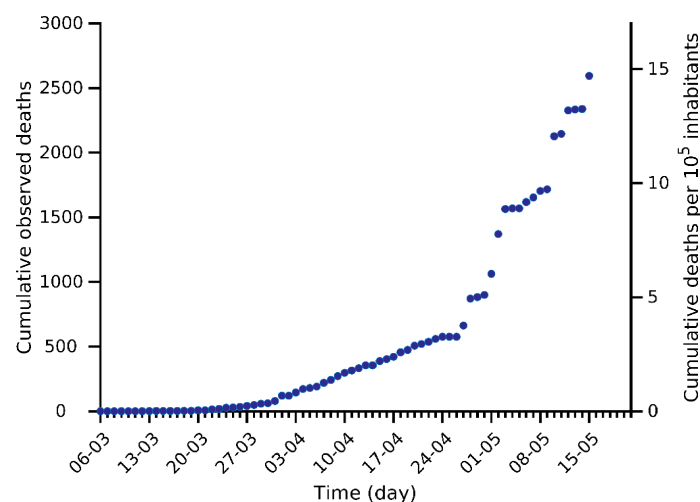
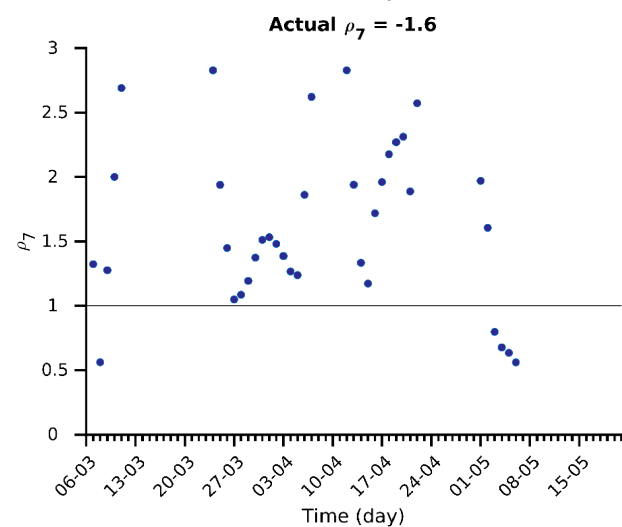
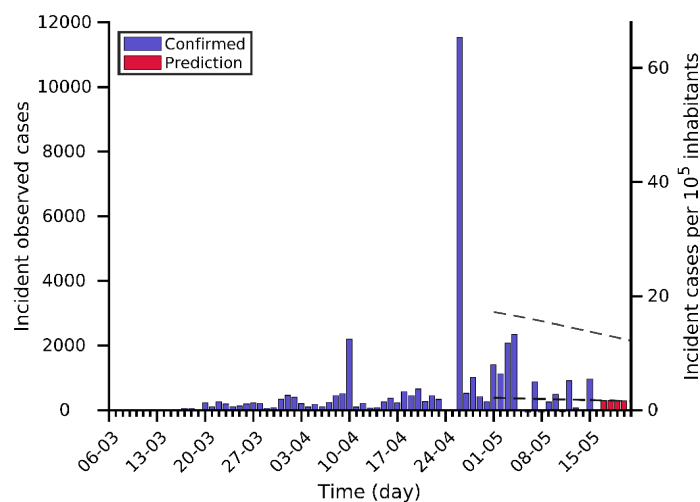
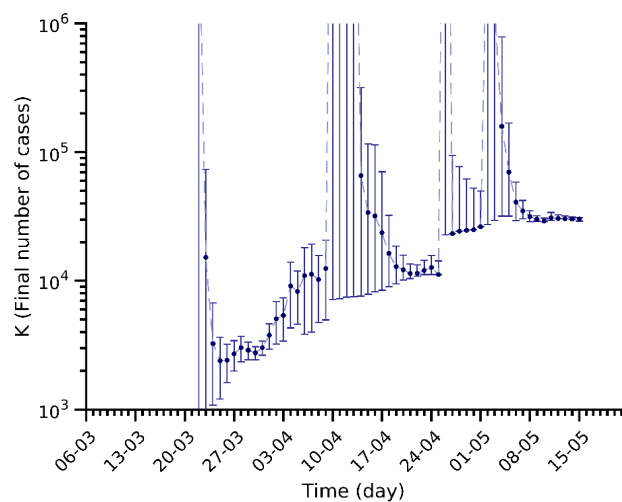
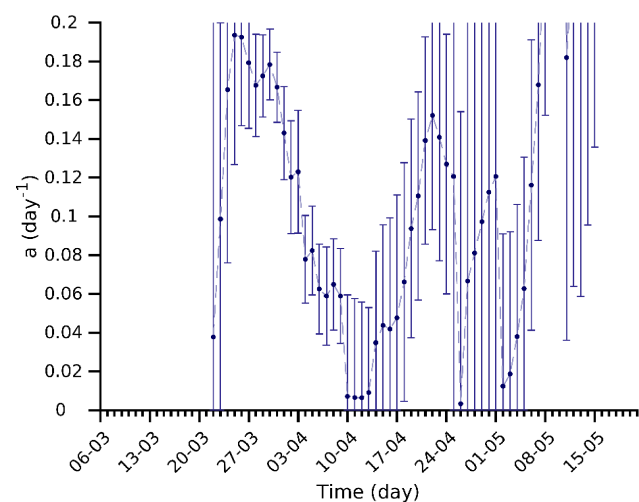
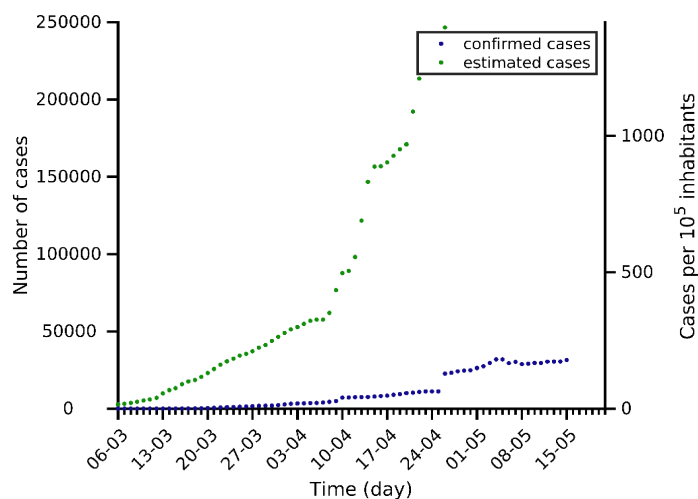
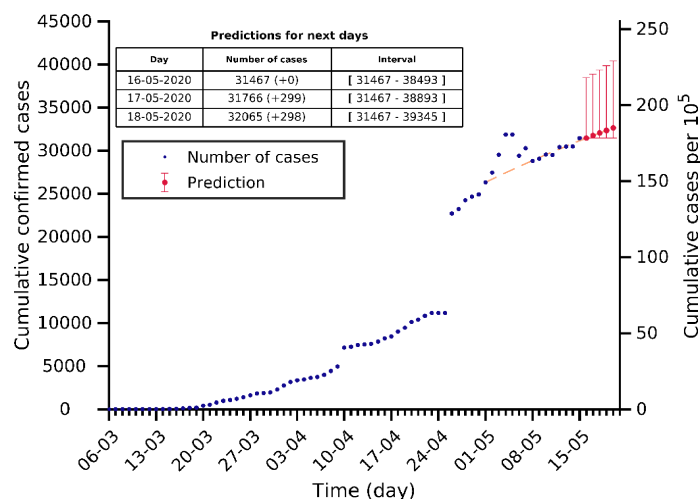
Chile 15-05-2020. Population: 19.1M. Current cumulated incidence: 207/10⁵



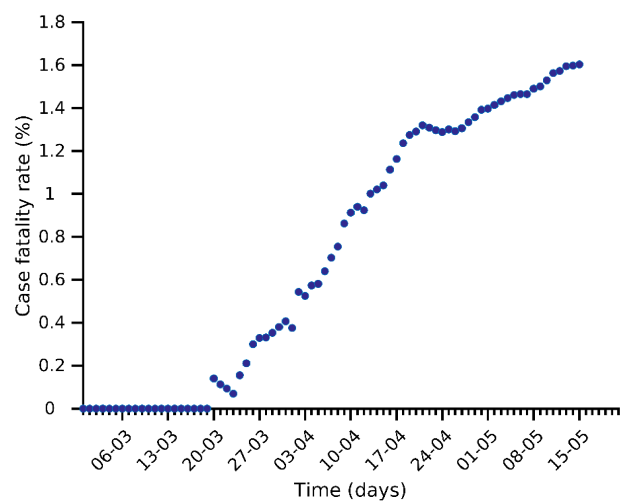
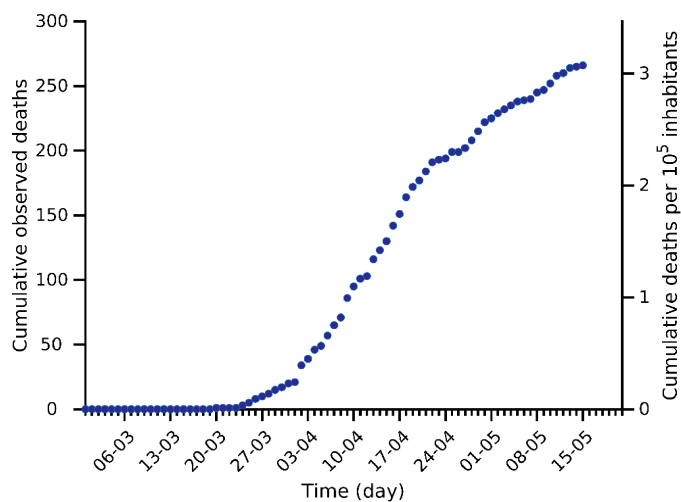
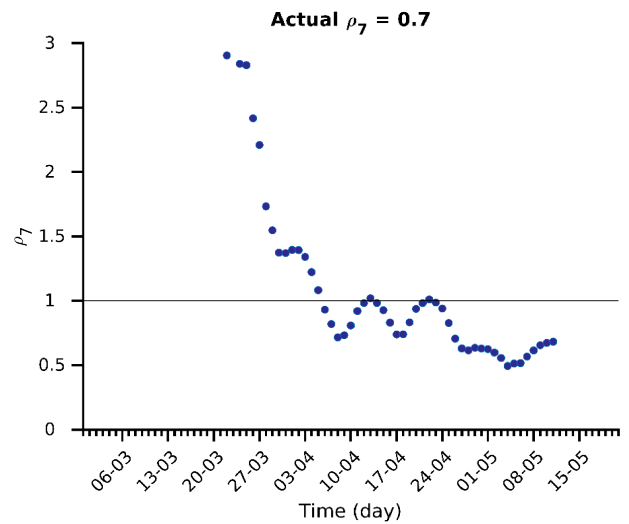
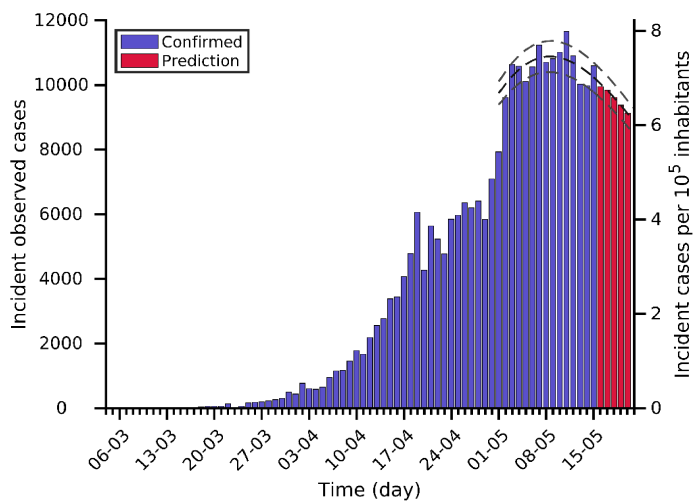
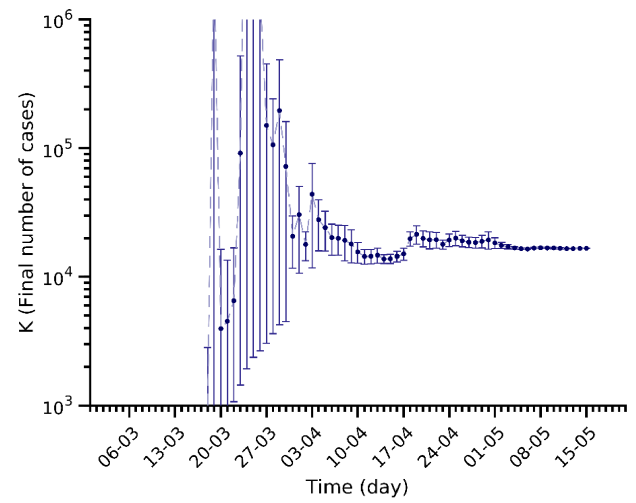
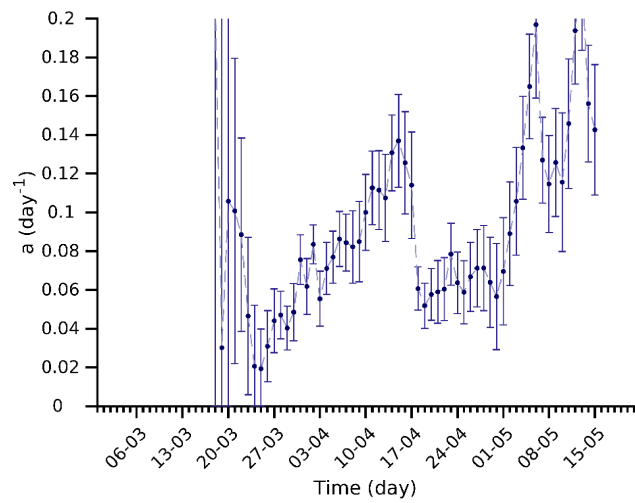
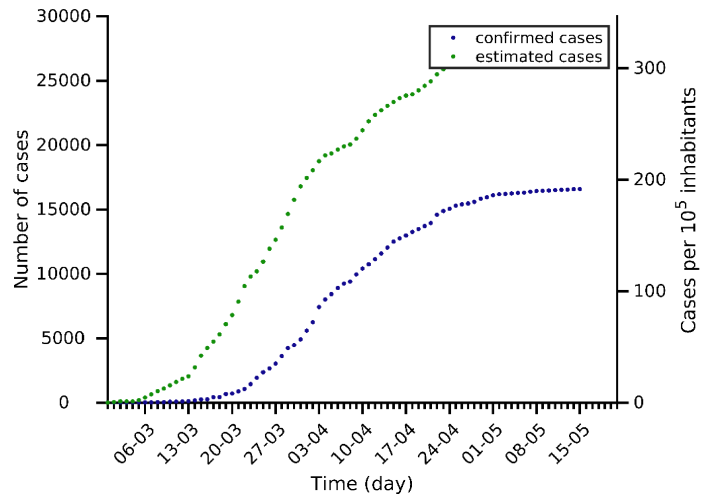
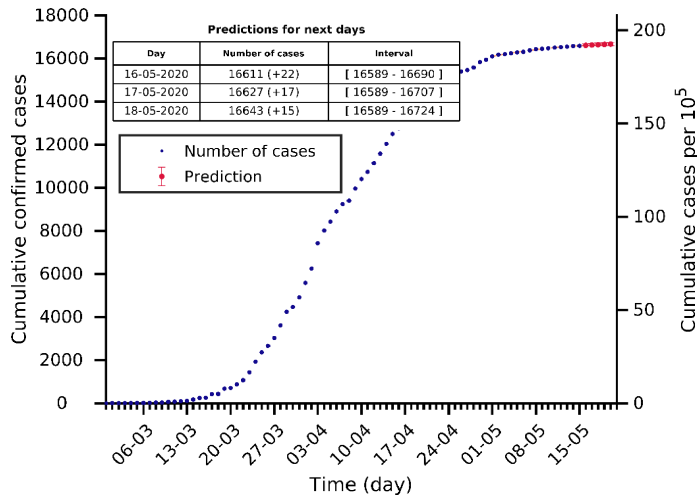
Pakistan 15-05-2020. Population: 220.9M. Current cumulated incidence: 18/10⁵



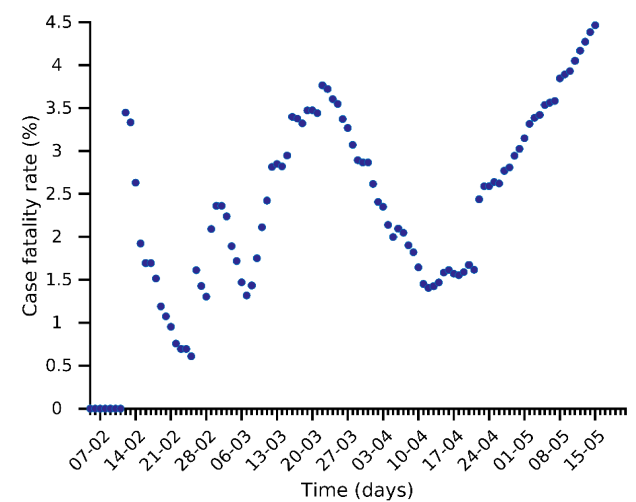
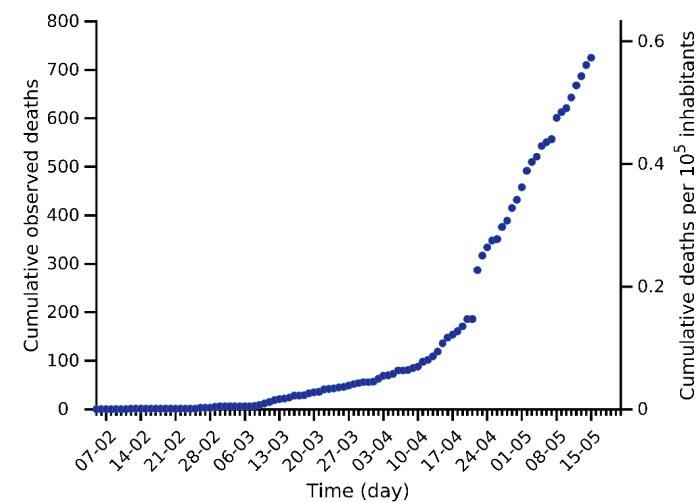
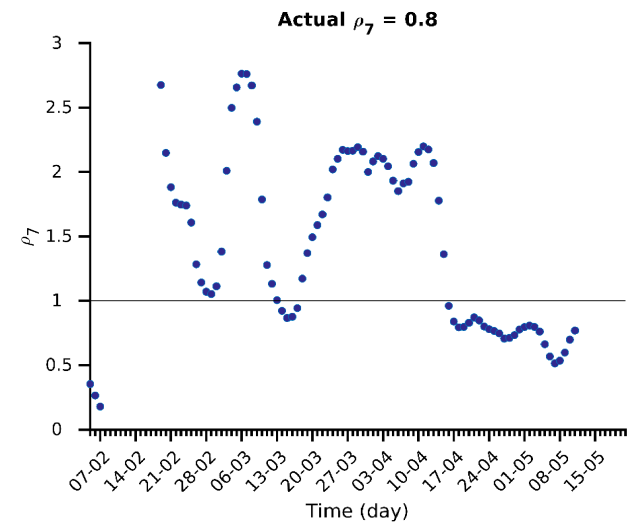
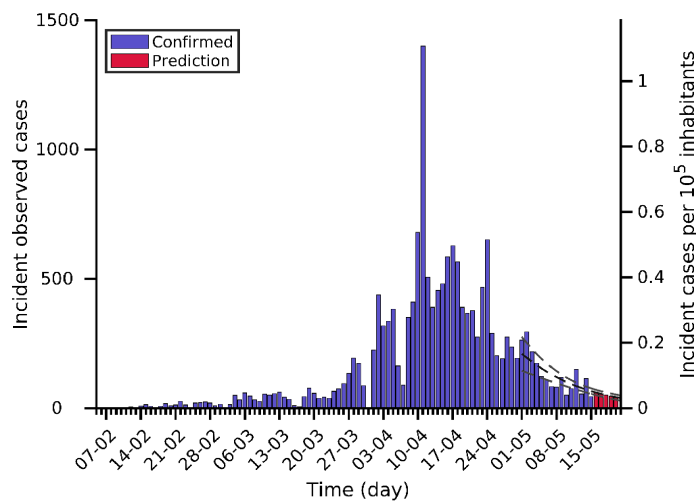
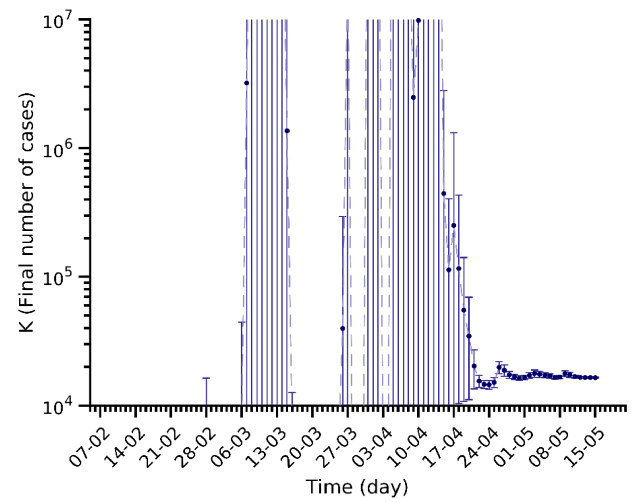
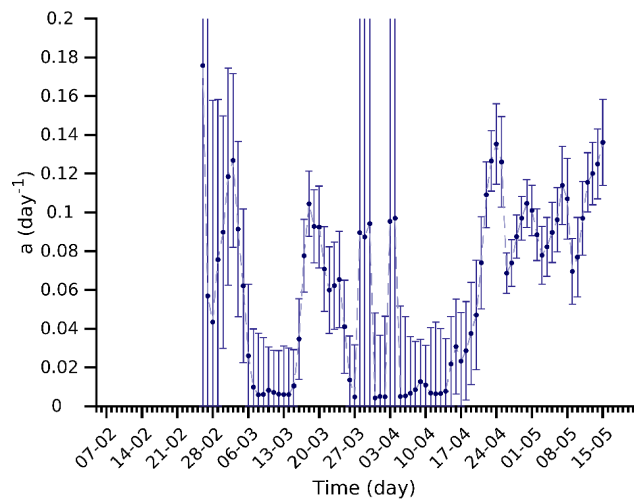
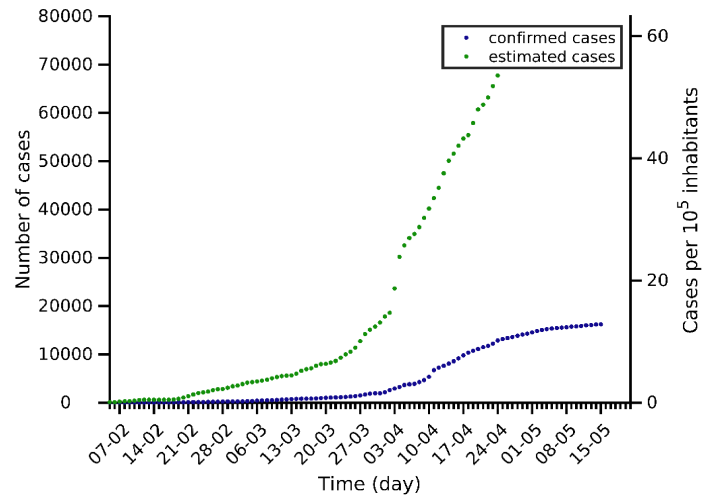
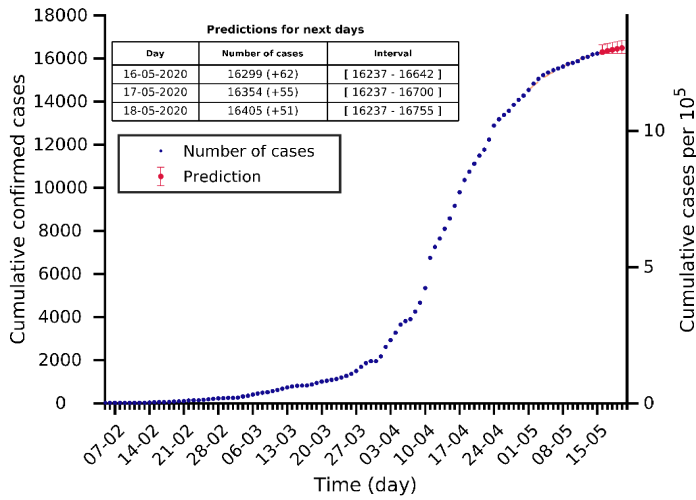
Ecuador 15-05-2020. Population: 17.6M. Current cumulated incidence: 178/10⁵



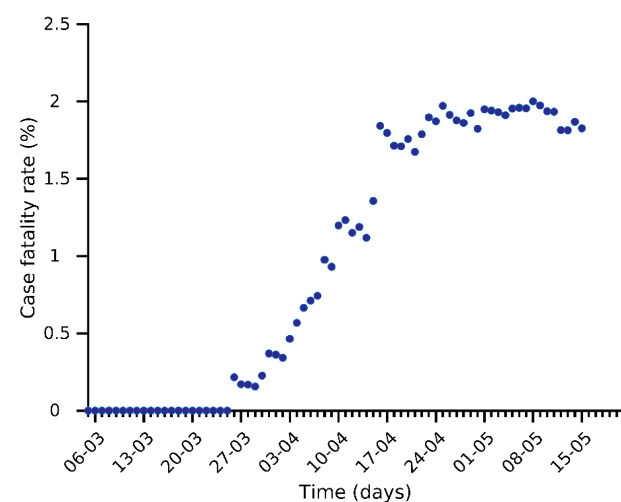
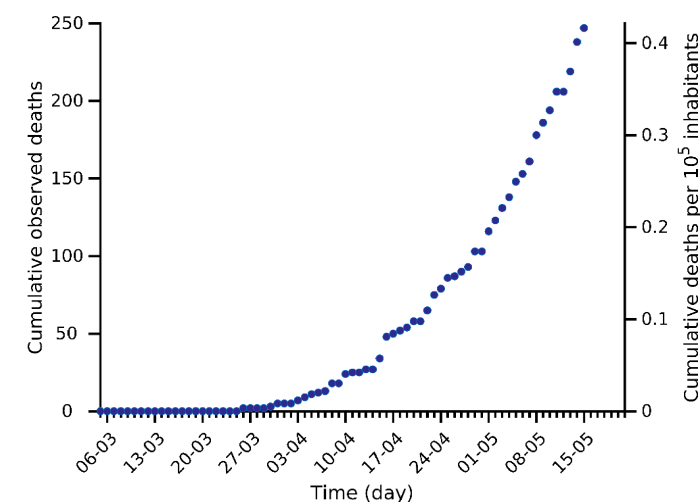
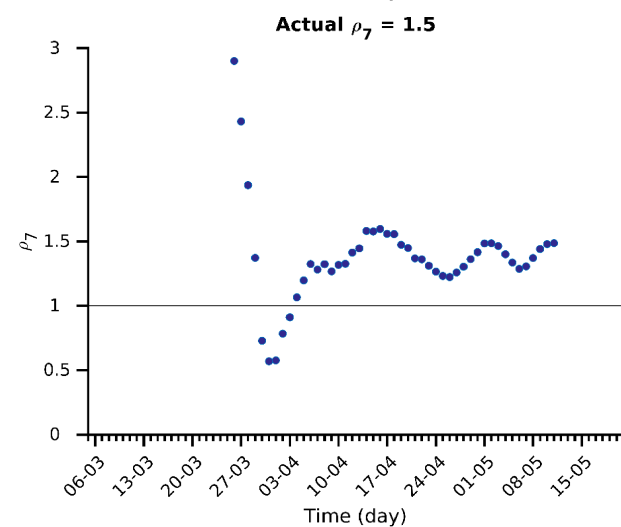
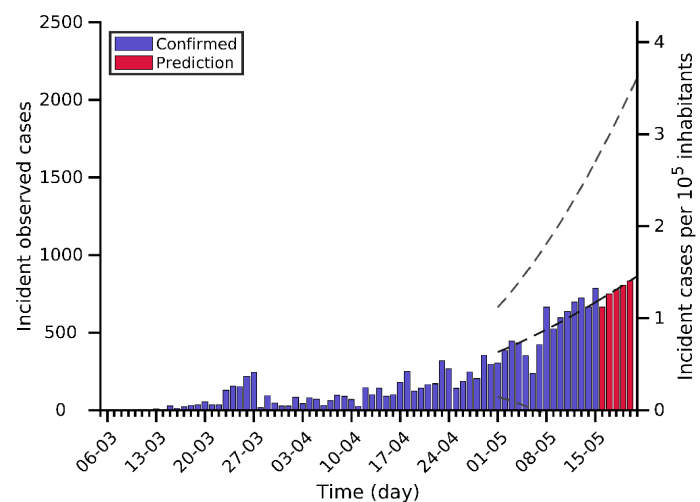
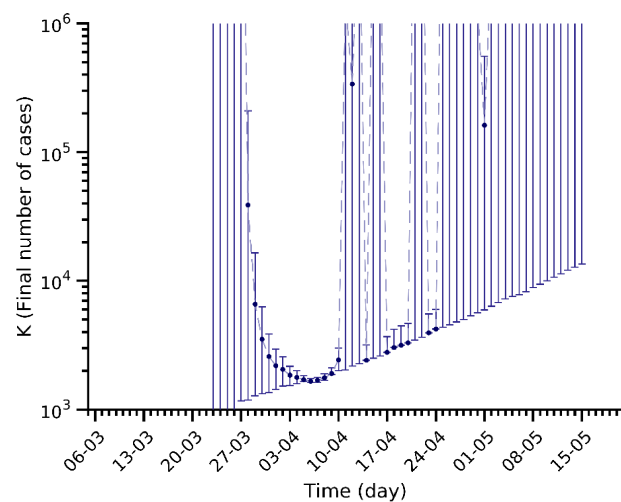
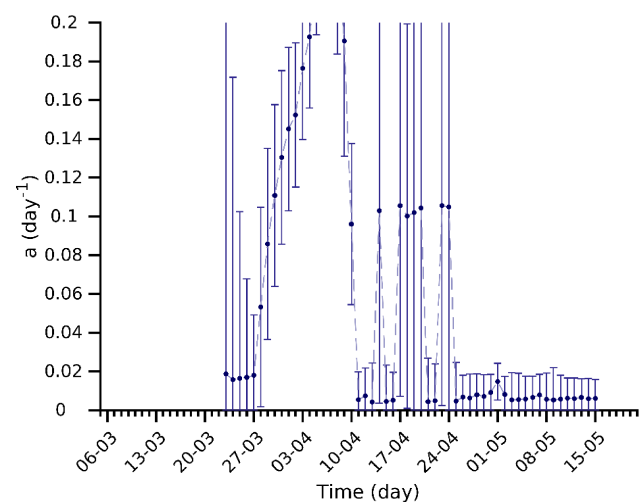
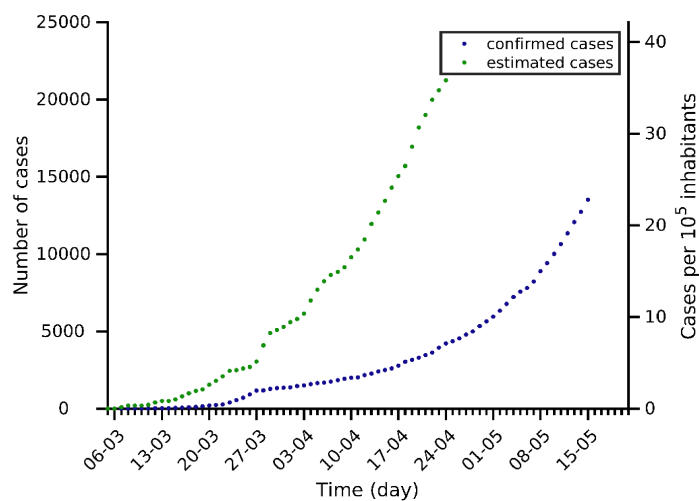
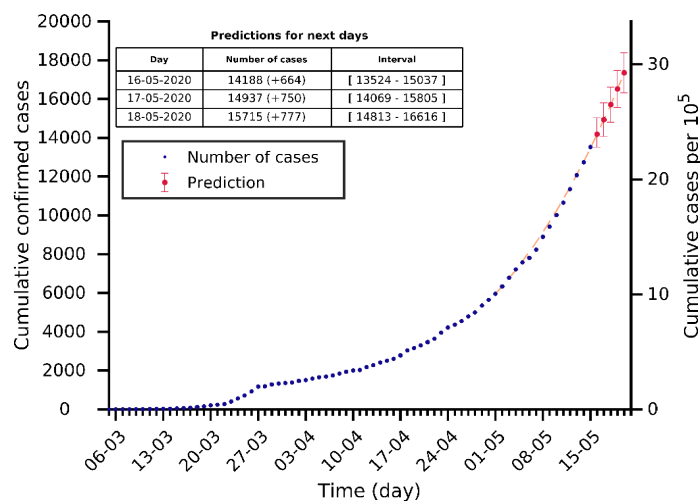
Israel 15-05-2020. Population: 8.7M. Current cumulated incidence: 192/10⁵



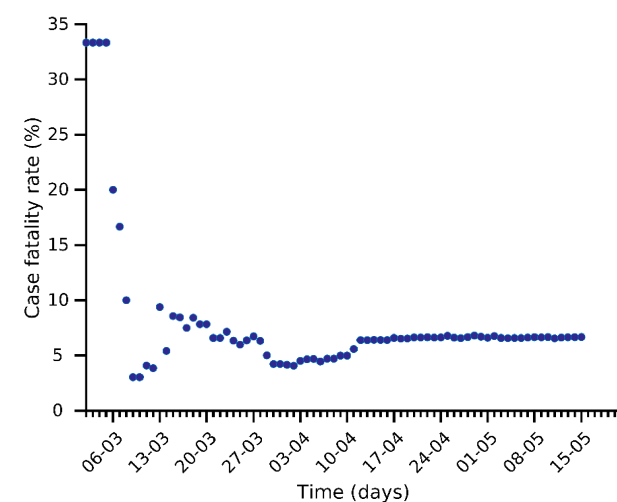
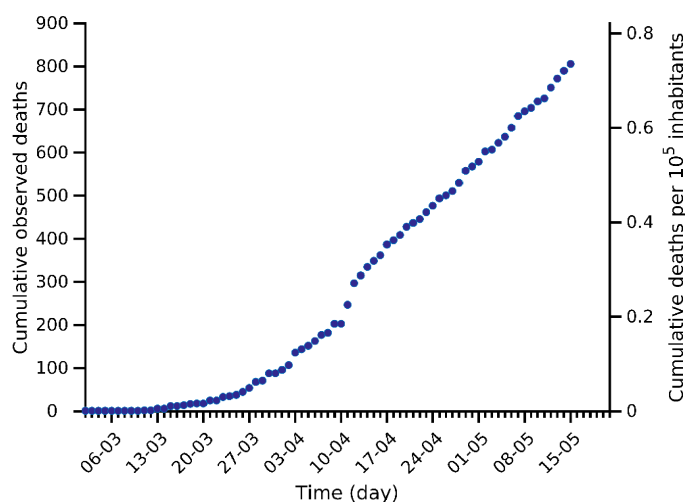
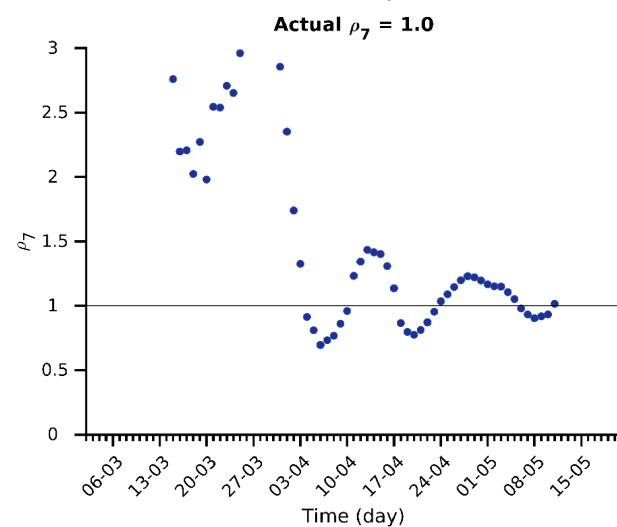
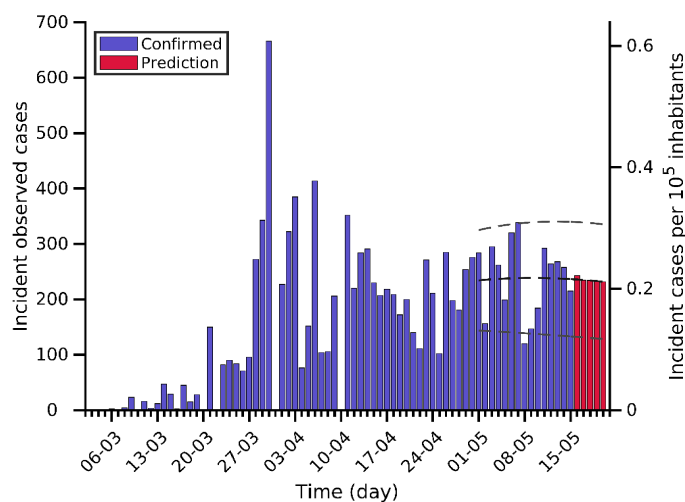
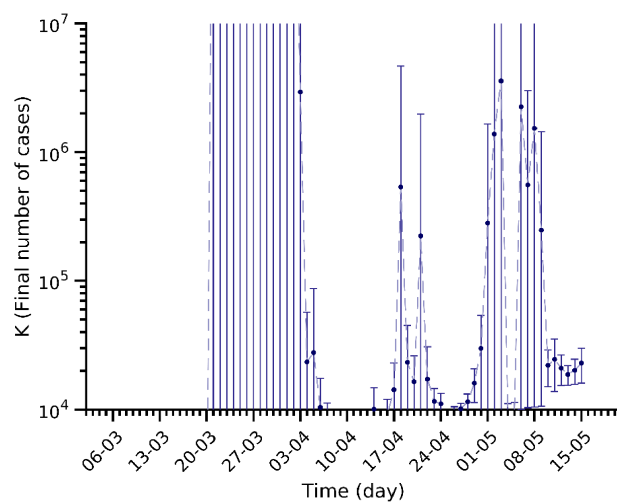
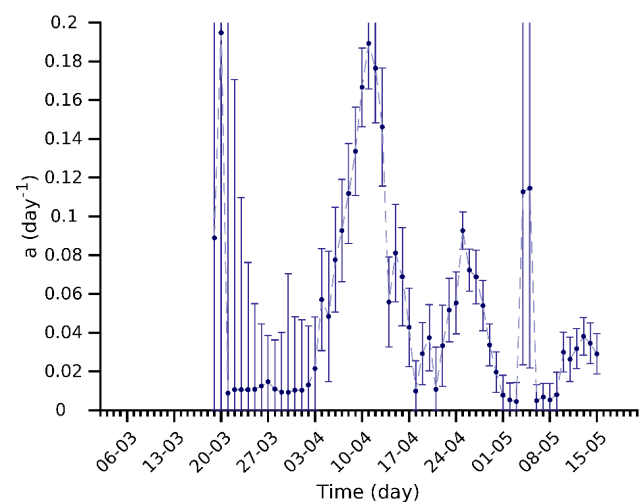
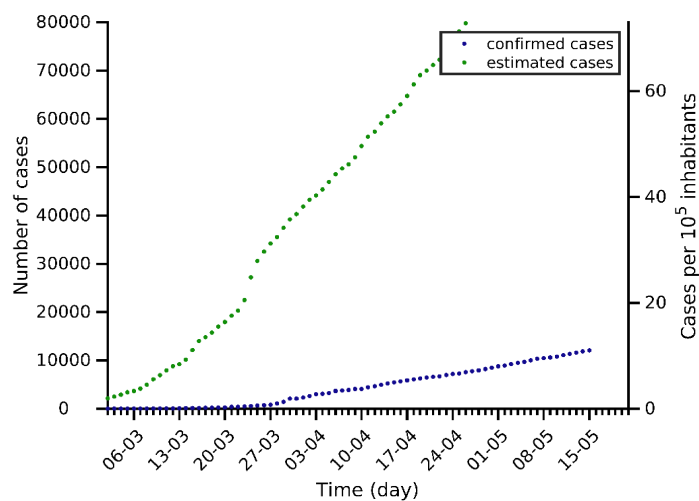
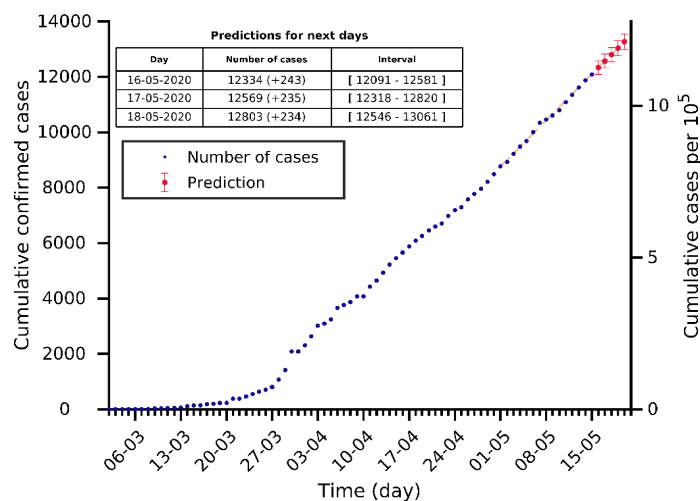
Japan 15-05-2020. Population: 126.5M. Current cumulated incidence: 13/10⁵



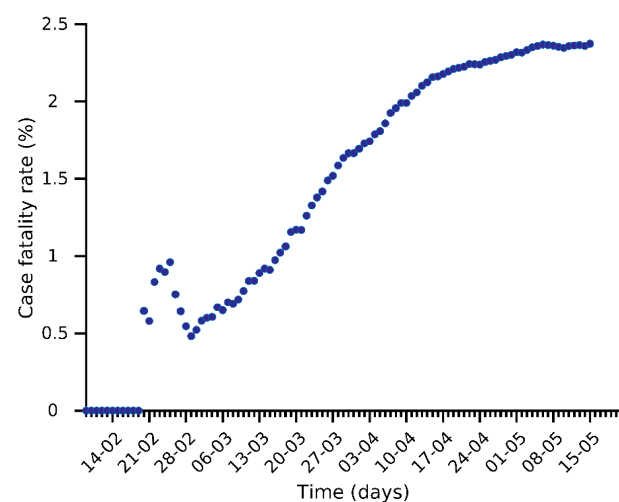
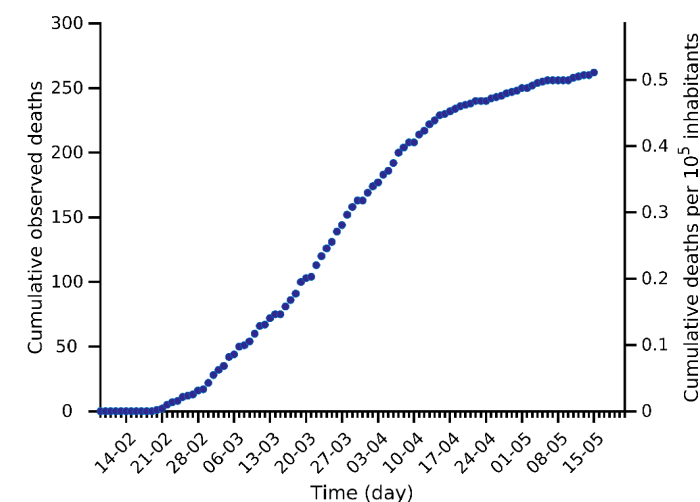
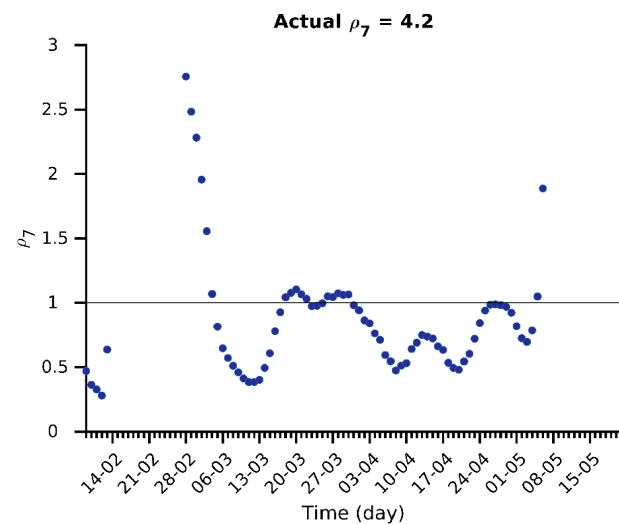
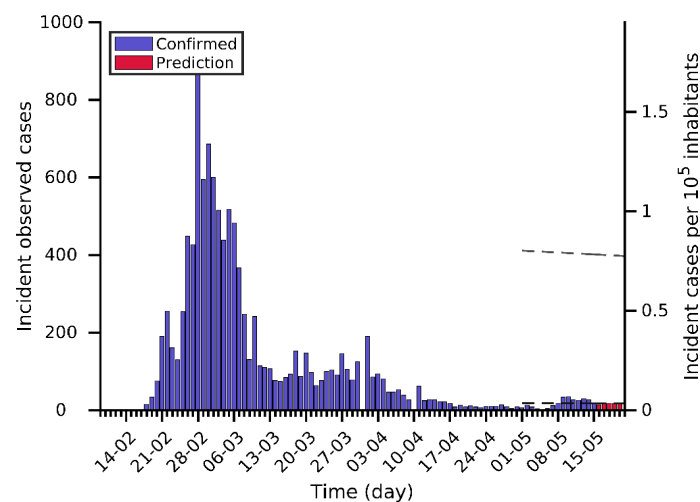
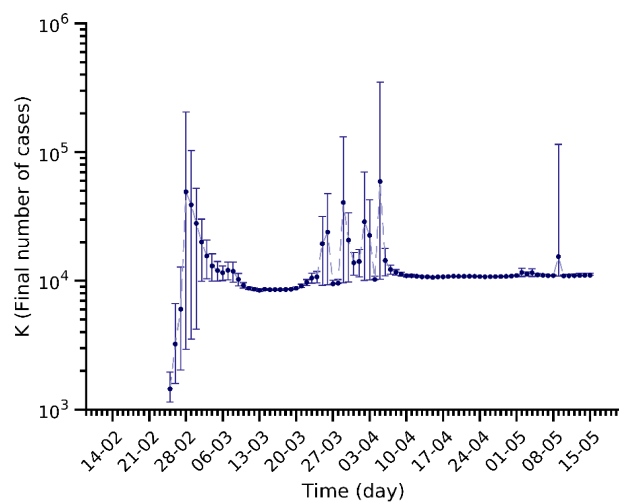
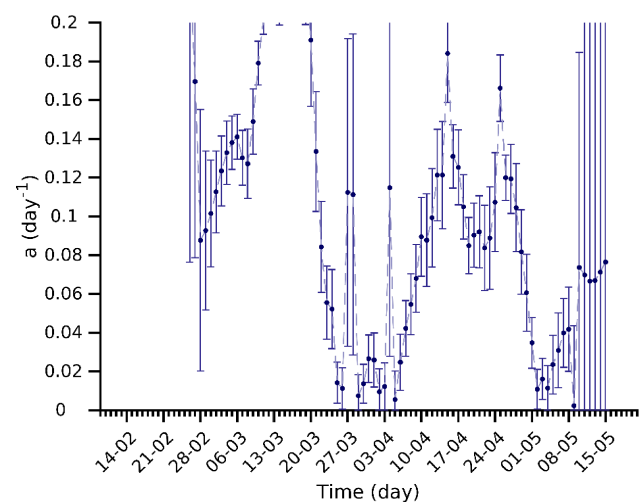
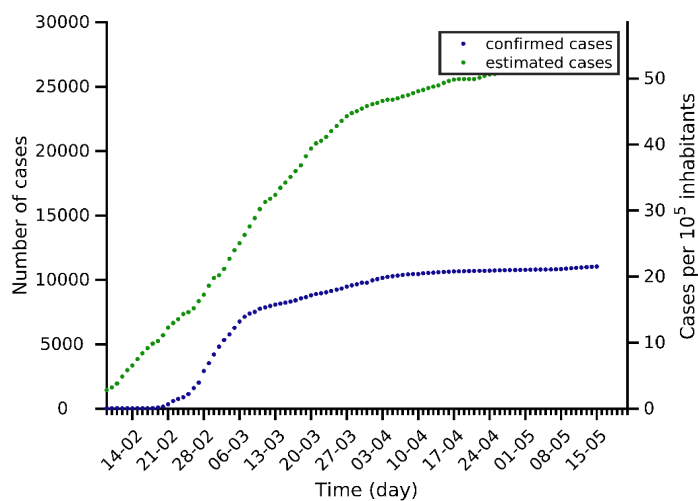
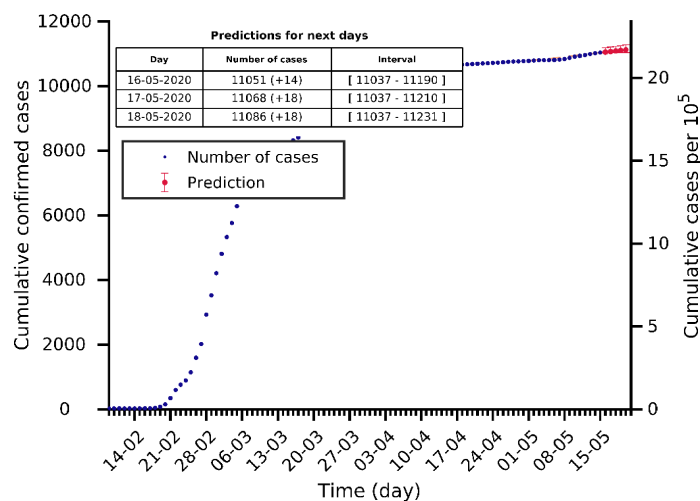
South Africa 15-05-2020. Population: 59.3M. Current cumulated incidence: 23/10⁵



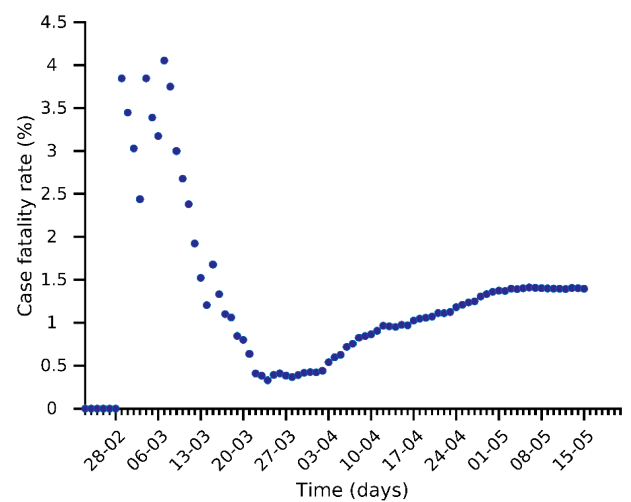
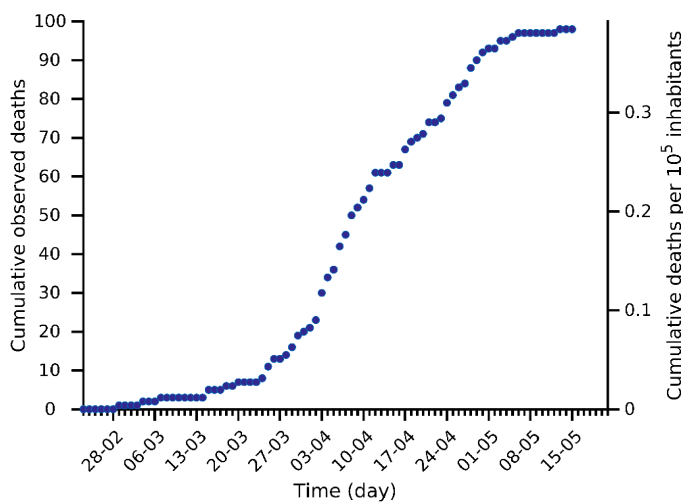
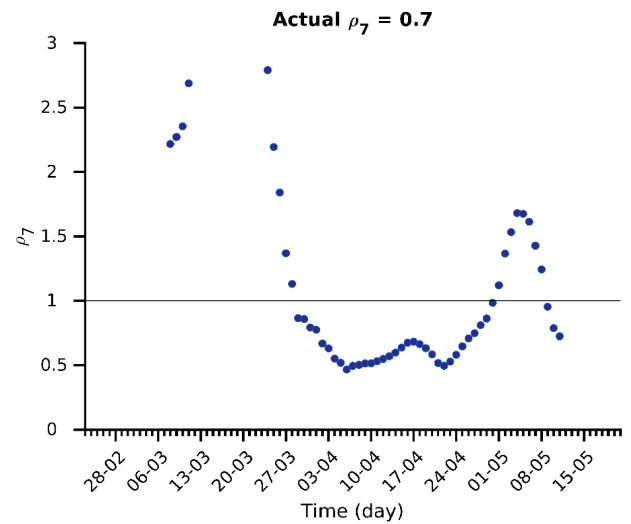
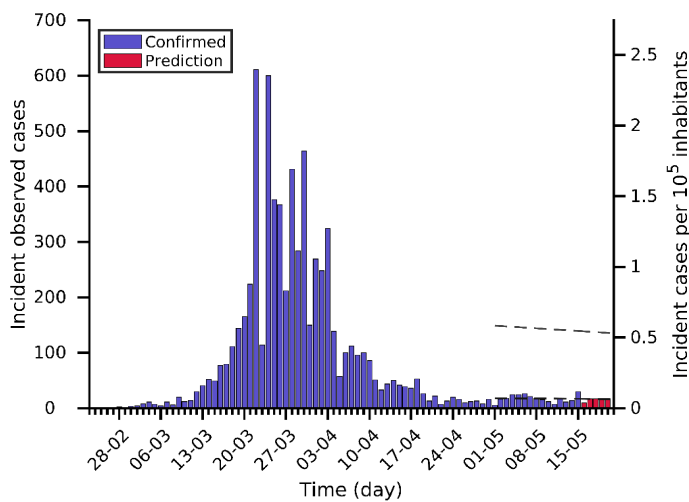
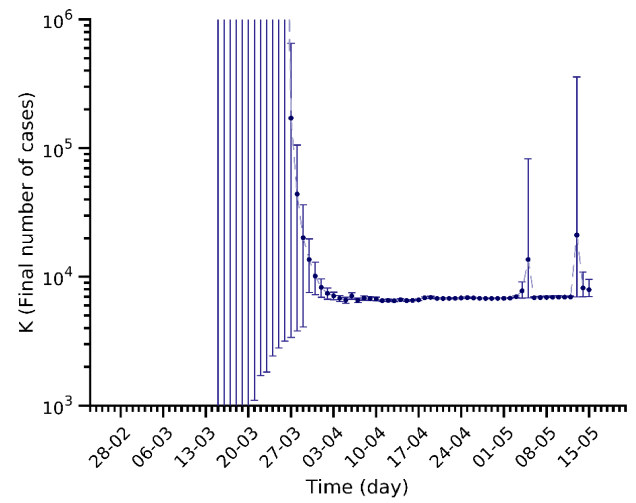
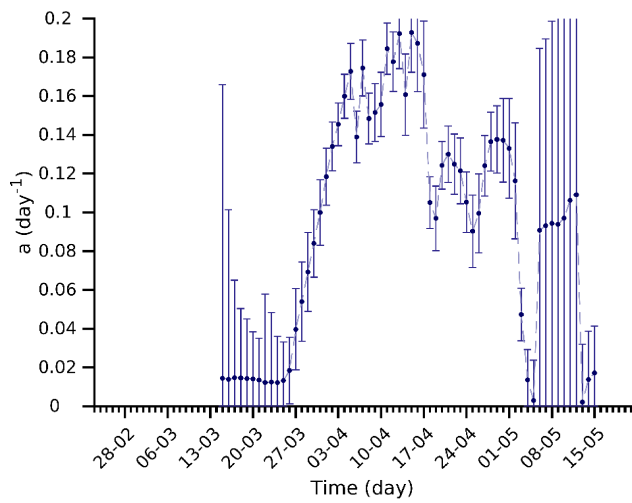
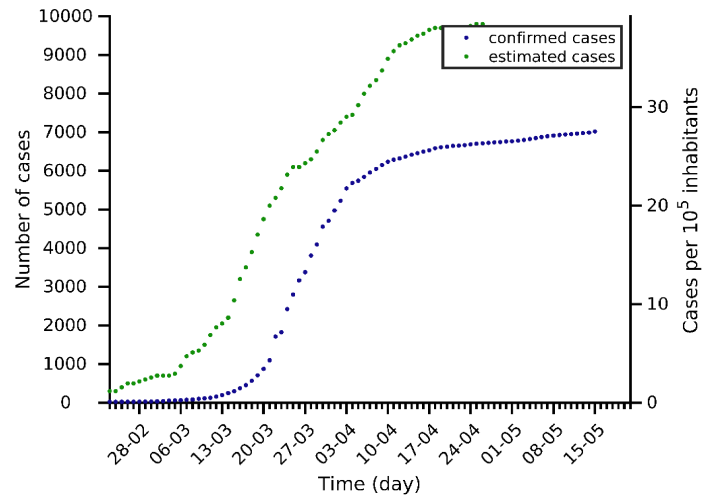
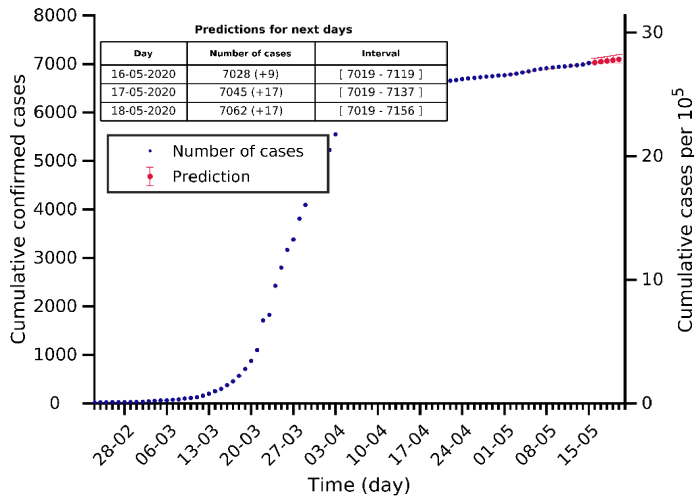
Philippines 15-05-2020. Population: 109.6M. Current cumulated incidence: 11/10⁵



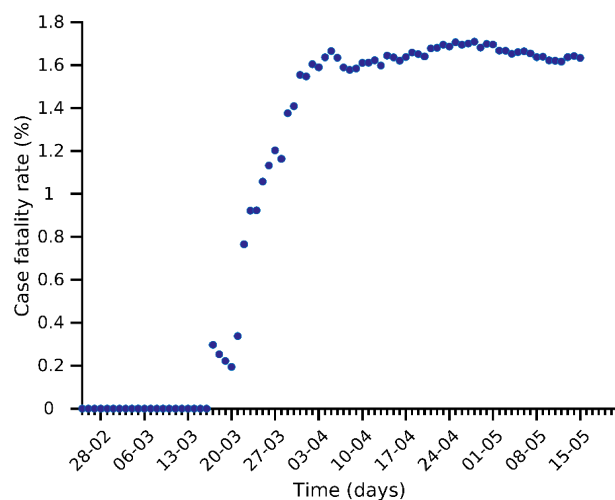
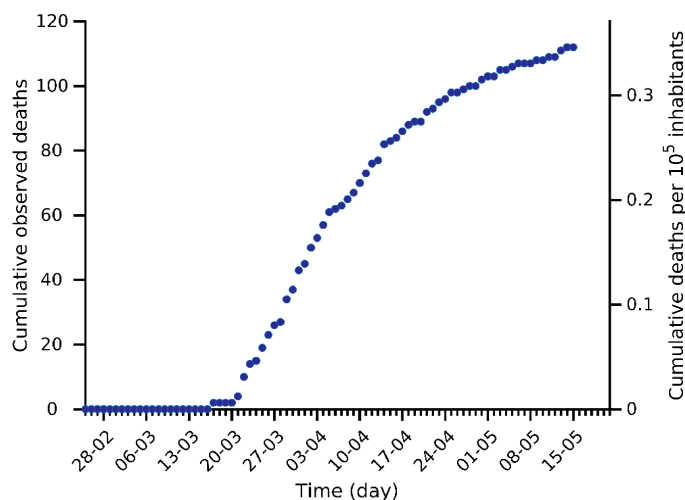
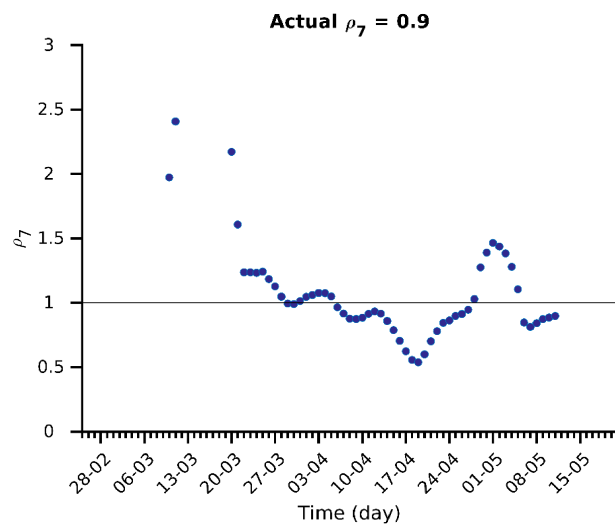
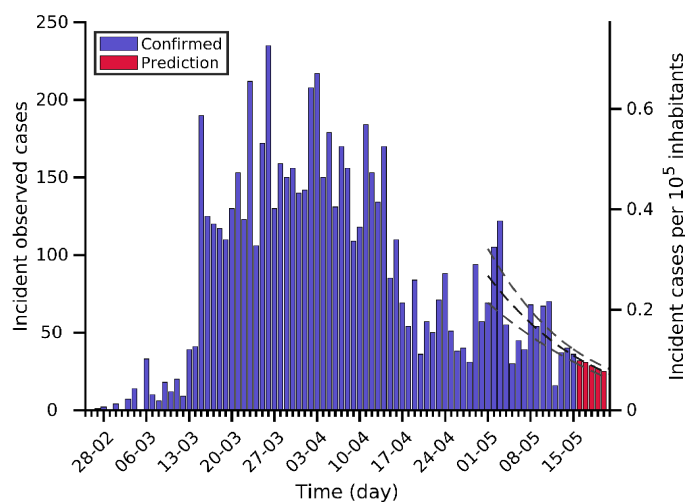
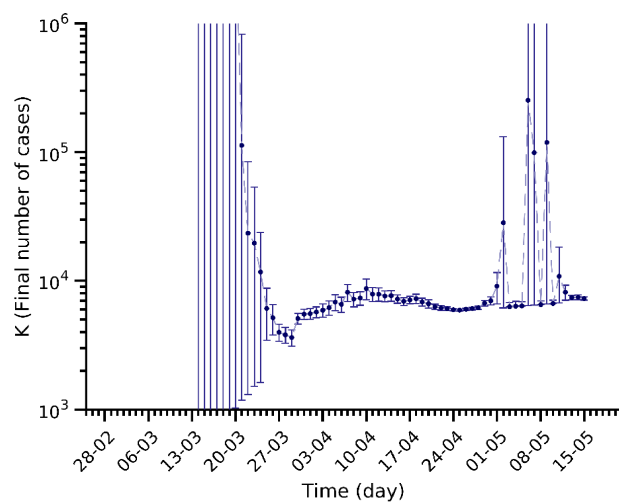
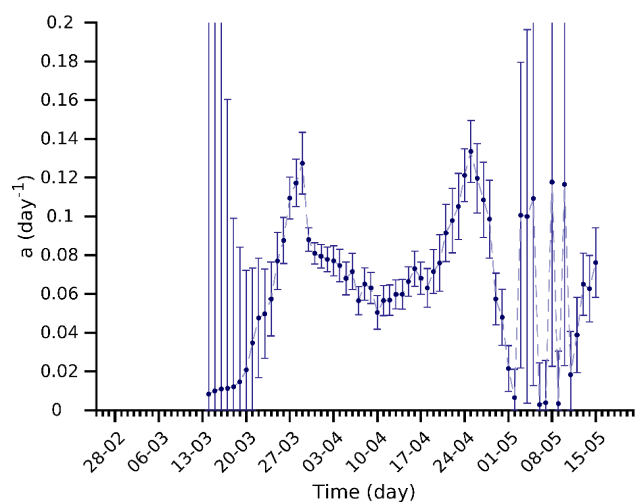
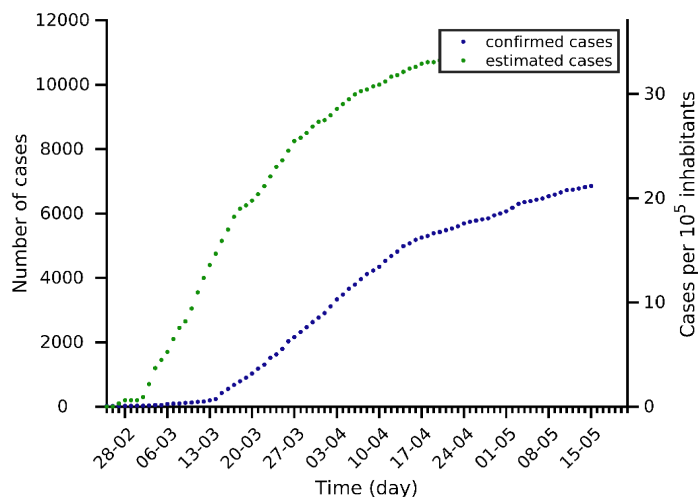
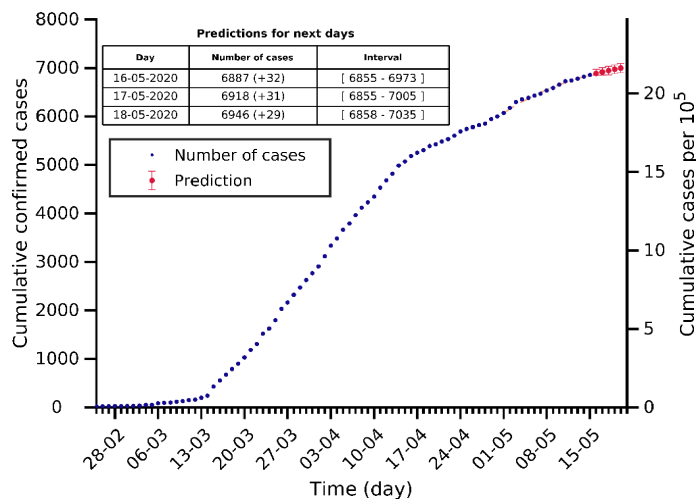
South Korea 15-05-2020. Population: 51.3M. Current cumulated incidence: 22/10⁵



Australia 15-05-2020. Population: 25.5M. Current cumulated incidence: 28/10⁵



Malaysia 15-05-2020. Population: 32.4M. Current cumulated incidence: 21/10⁵

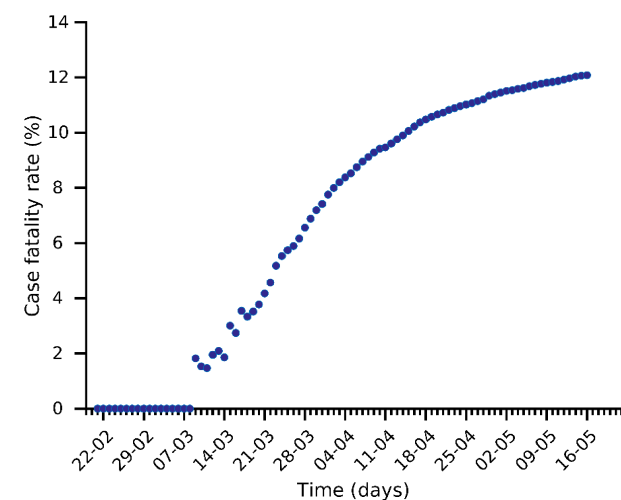
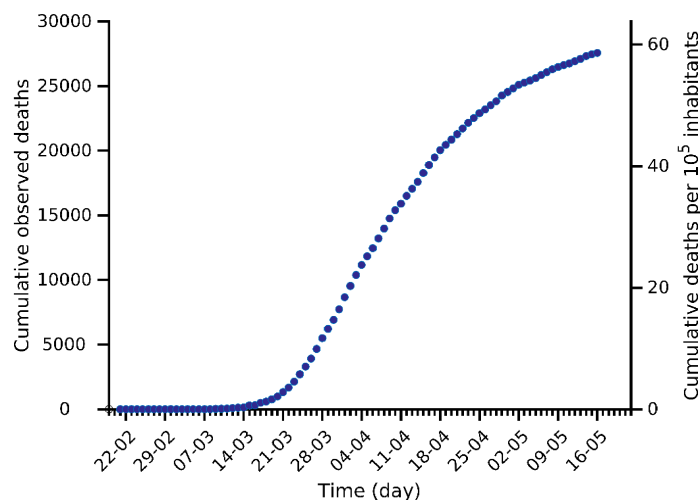
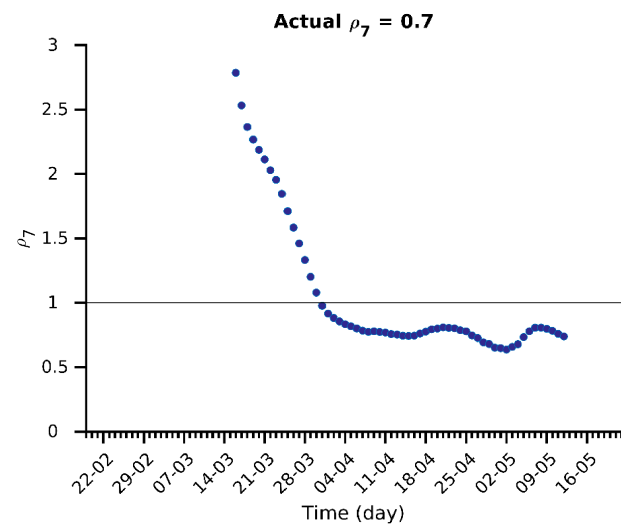
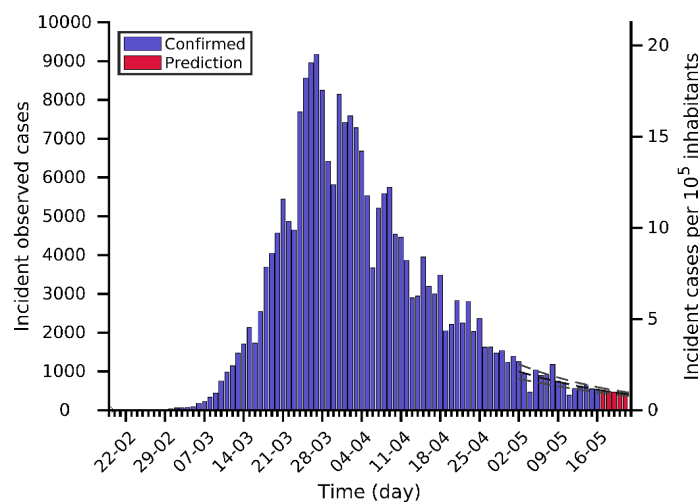
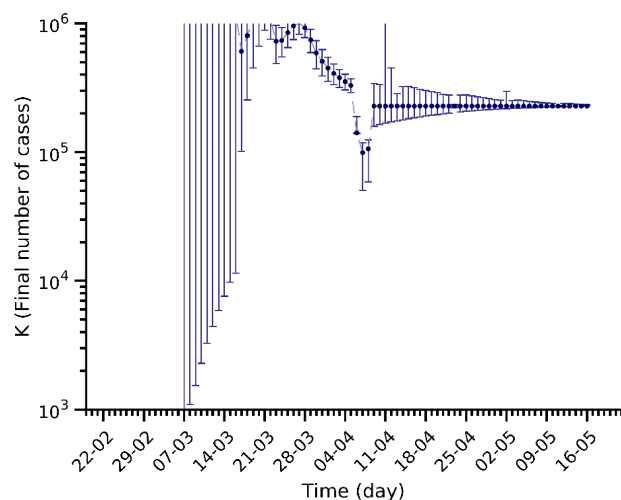
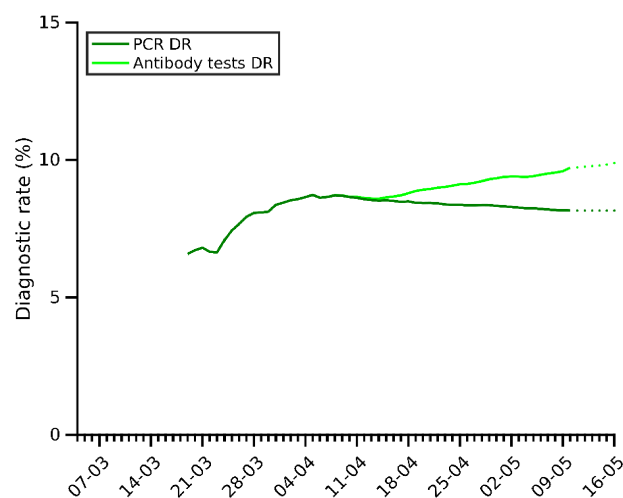
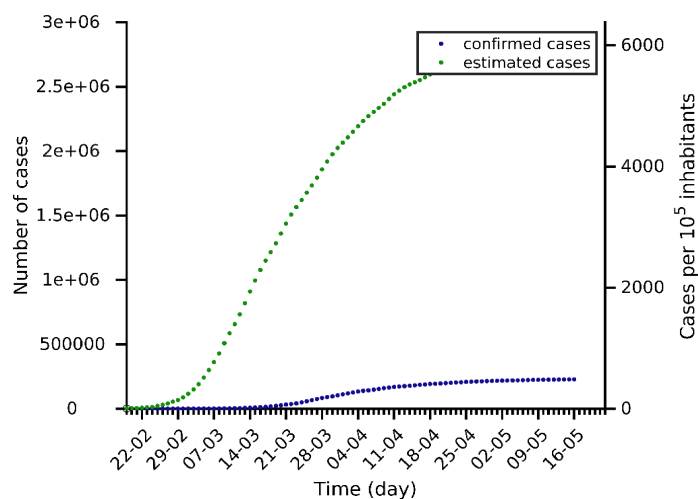
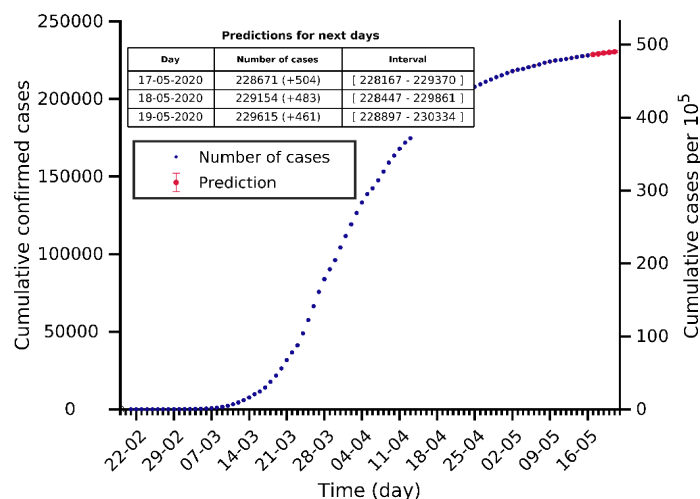


(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

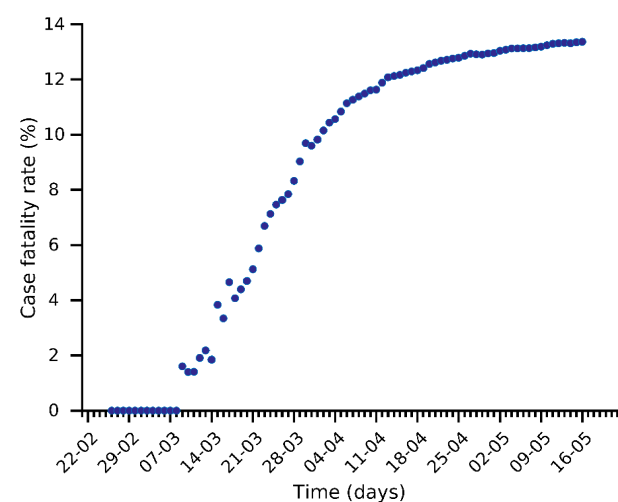
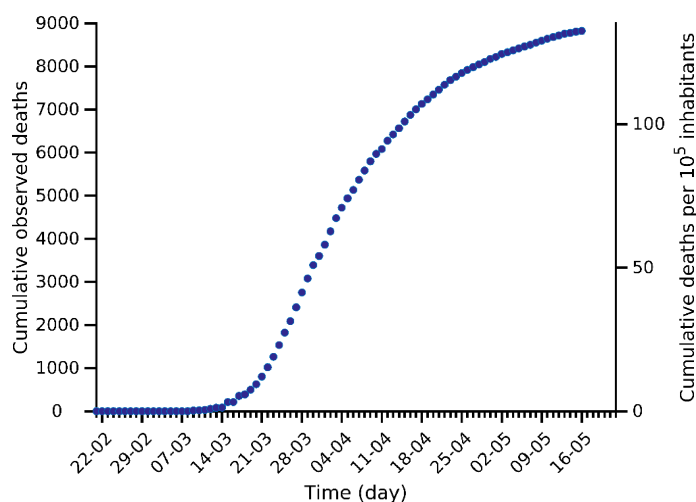
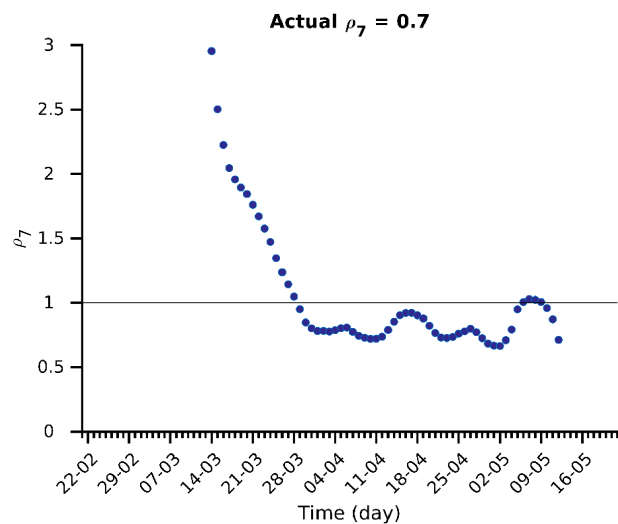
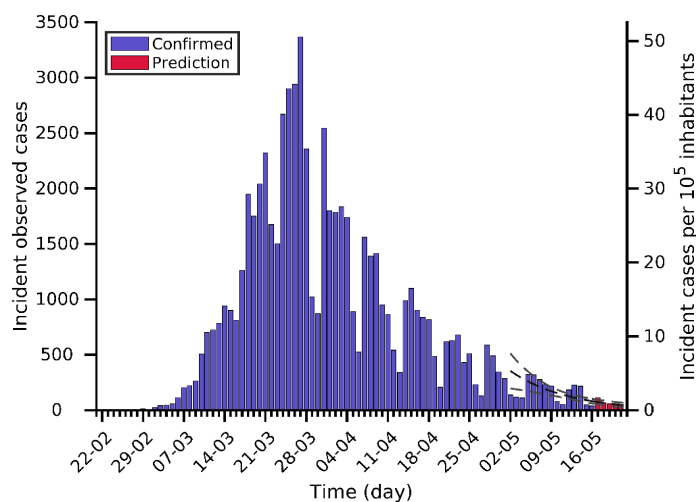
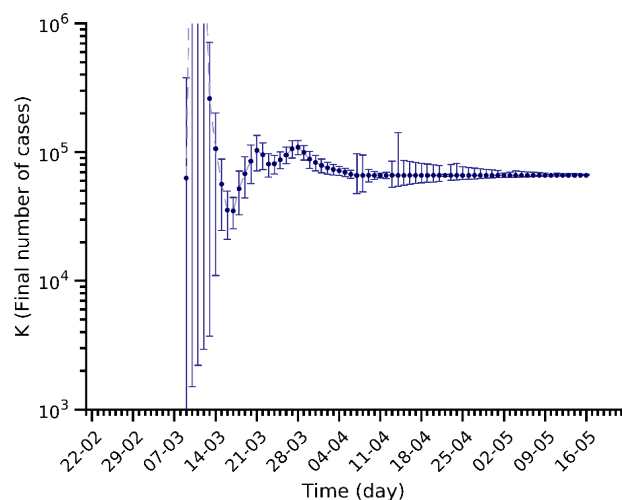
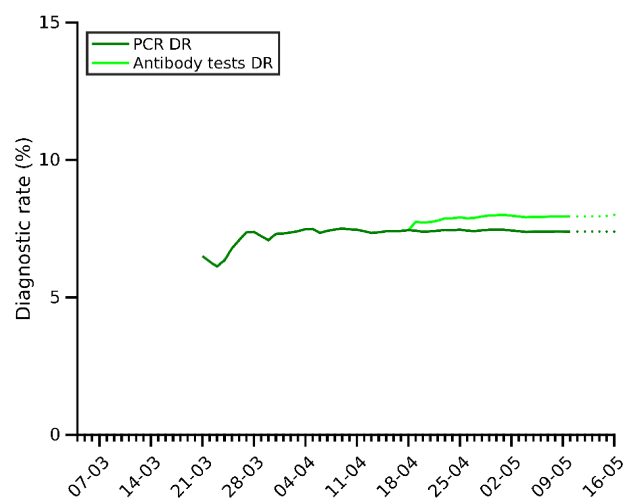
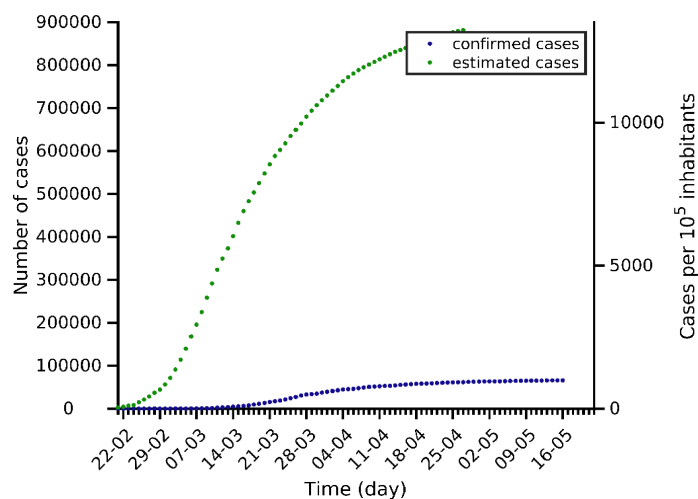
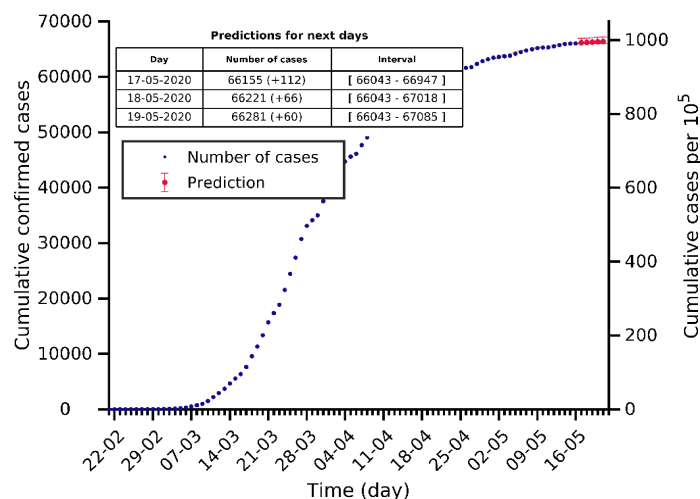
**WARNING: Data from Catalunya and Spain
are provisional, pending on the indication to
locate 2715 old cases.**

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and
<https://covid19.isciii.es/>

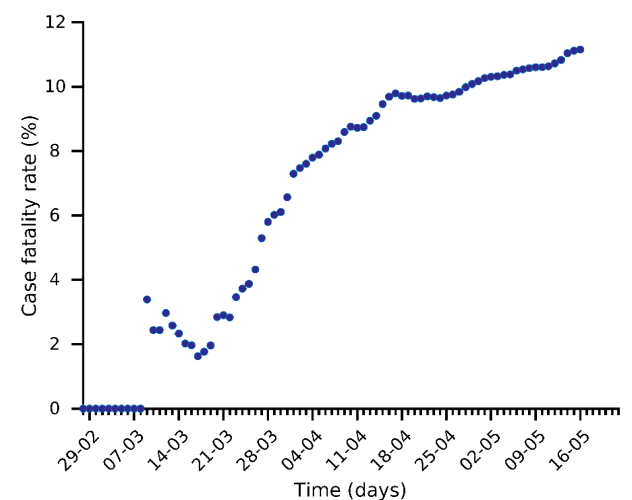
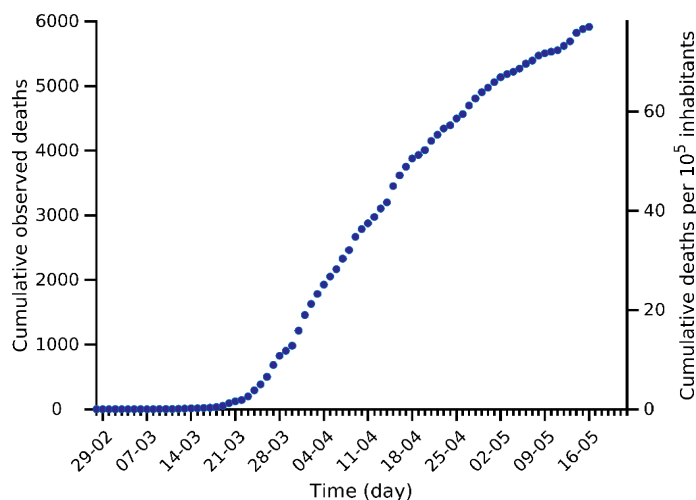
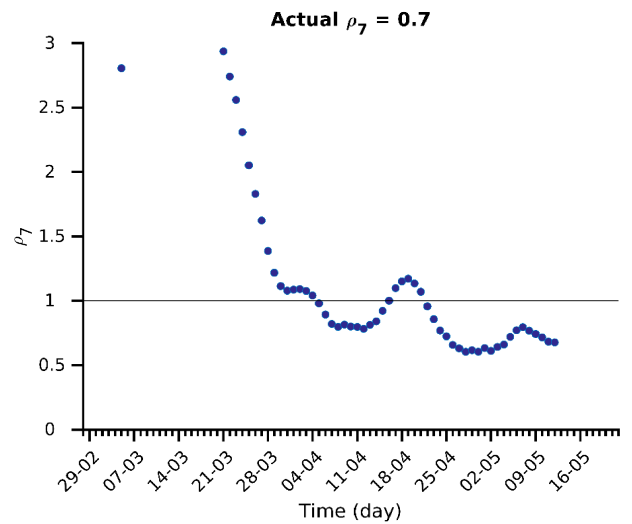
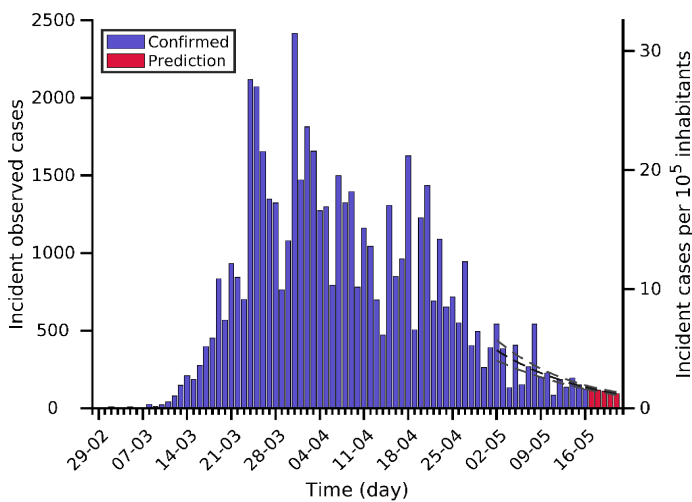
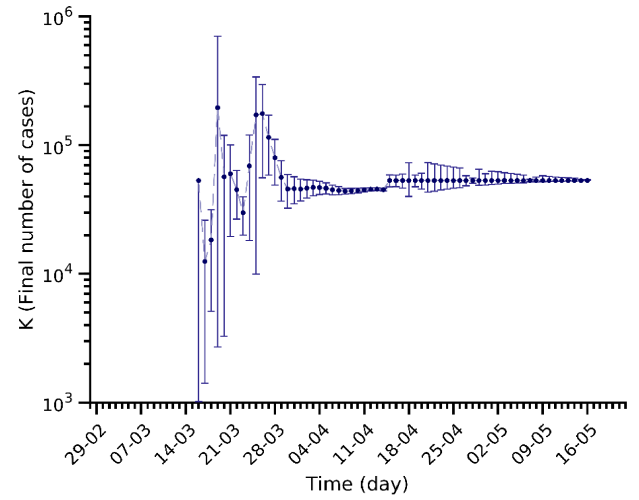
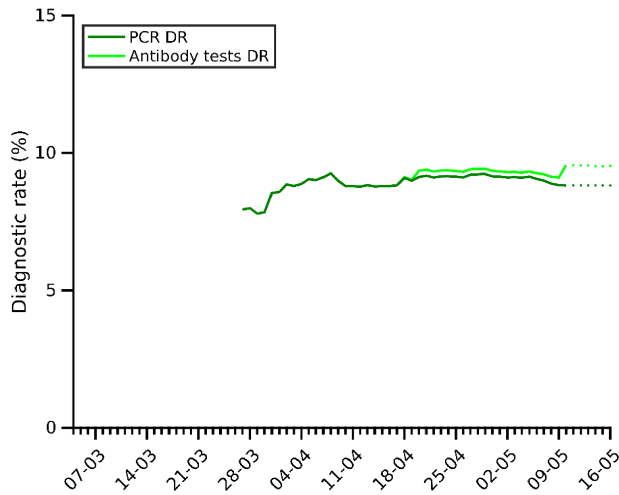
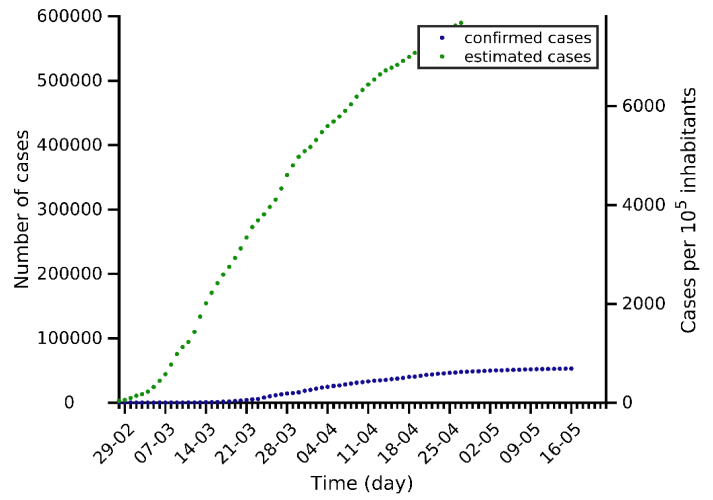
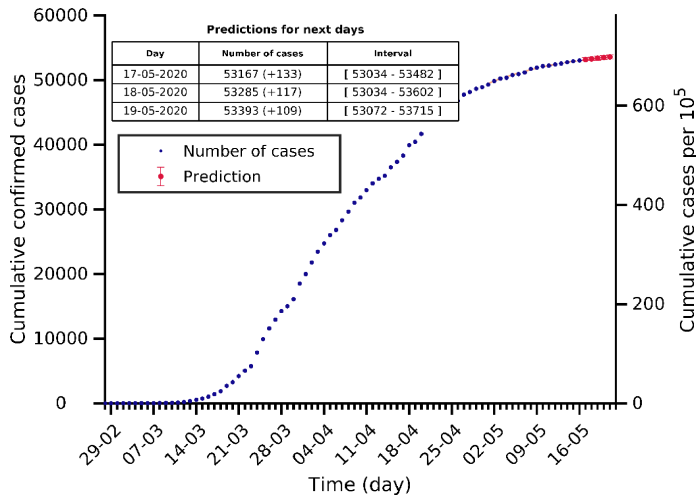
Spain 16-05-2020. Population: 47.0M. Current cumulated incidence: 485/10⁵



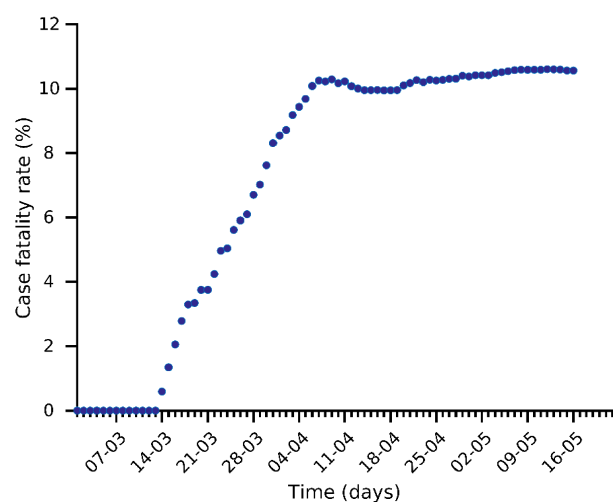
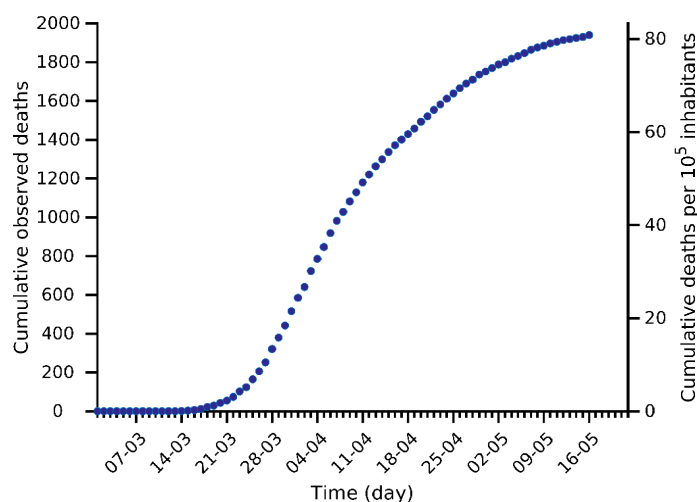
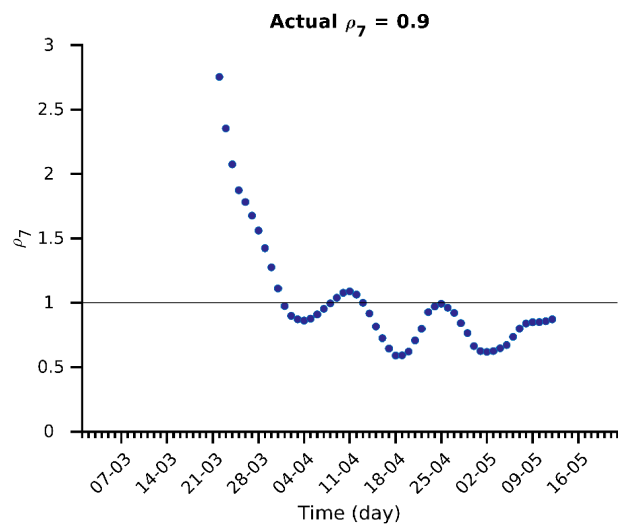
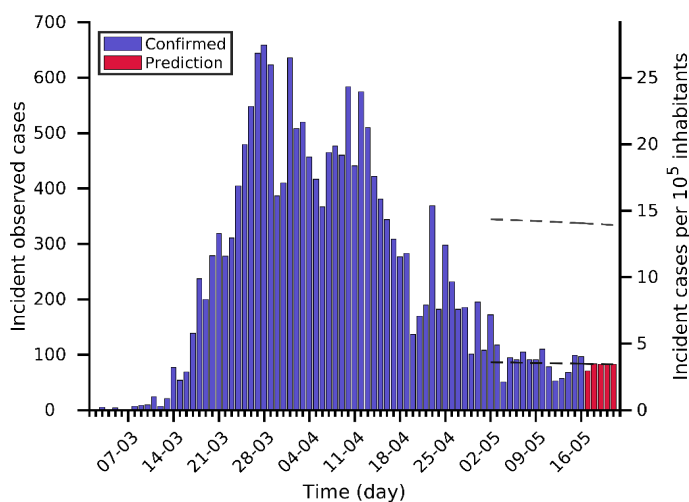
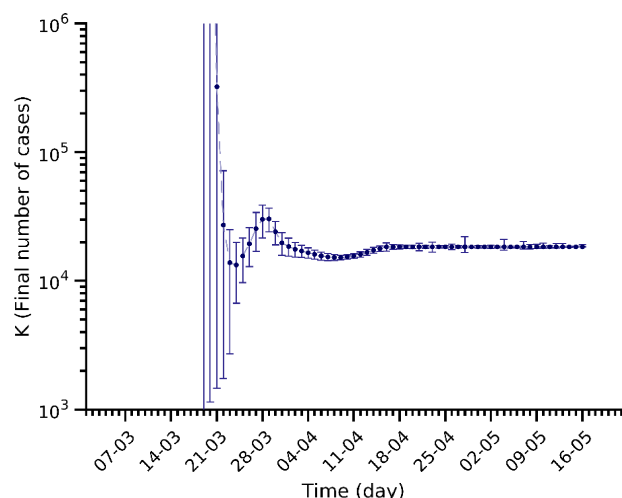
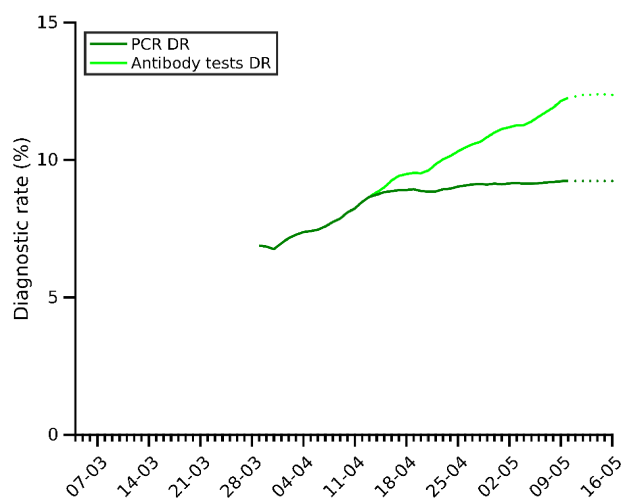
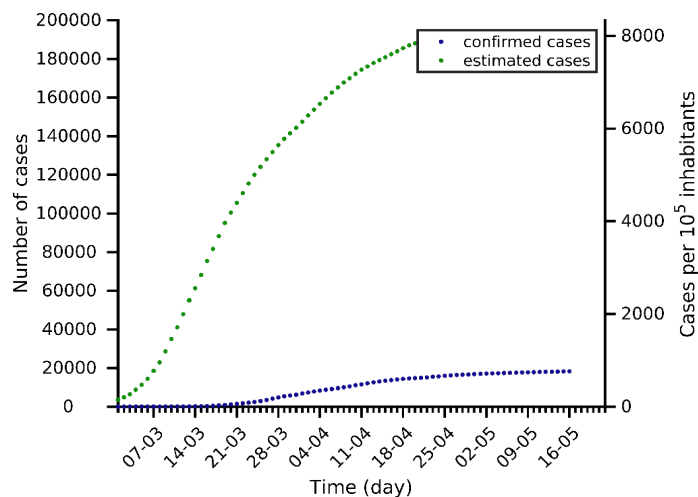
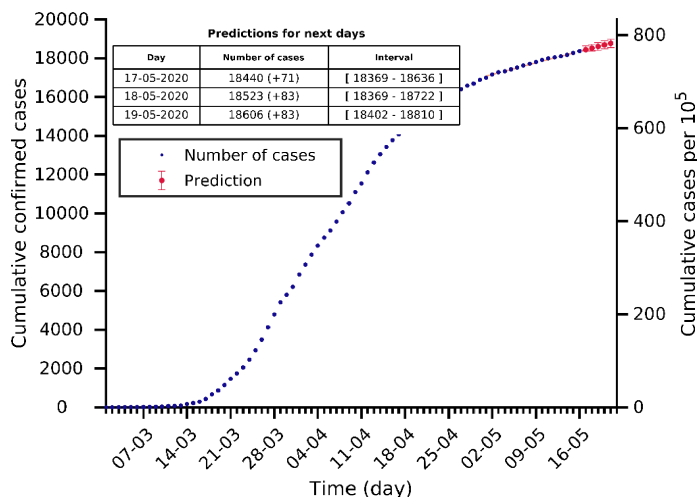
Madrid 16-05-2020. Population: 6.7M. Current cumulated incidence: 991/10⁵



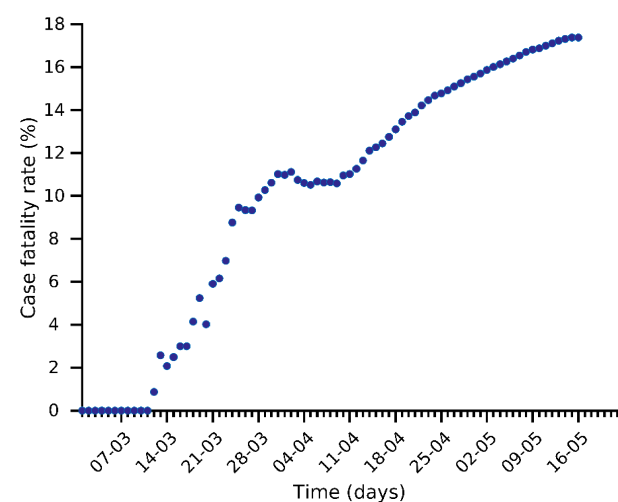
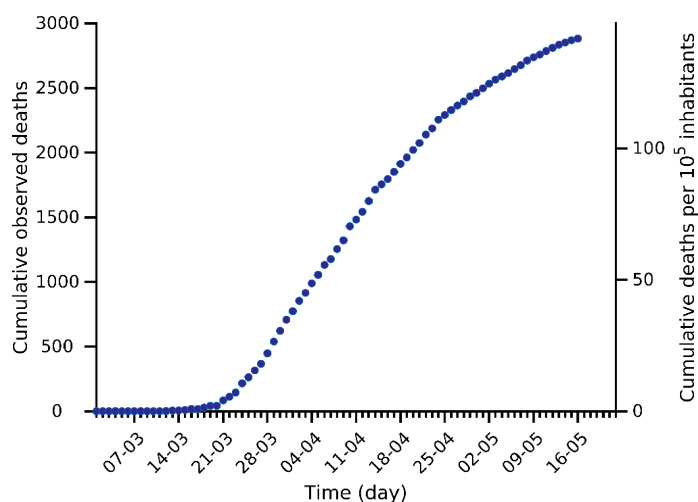
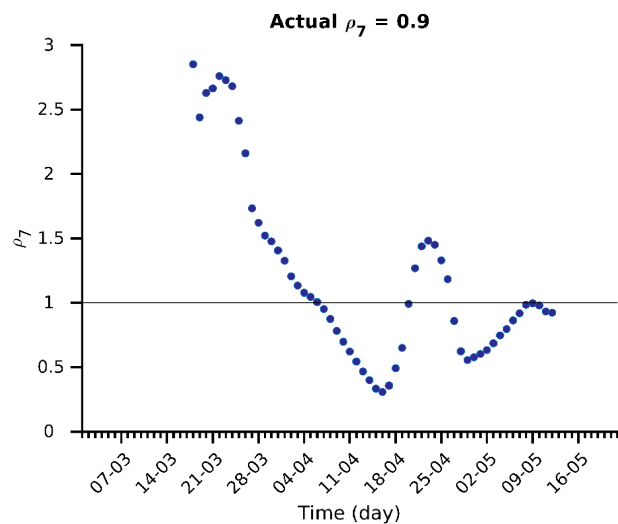
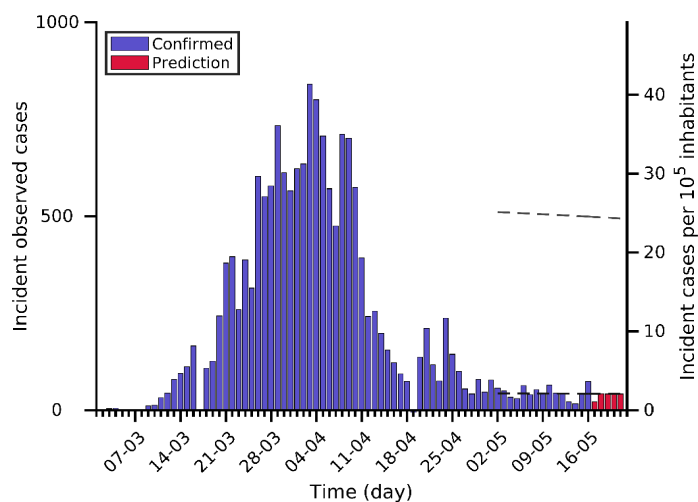
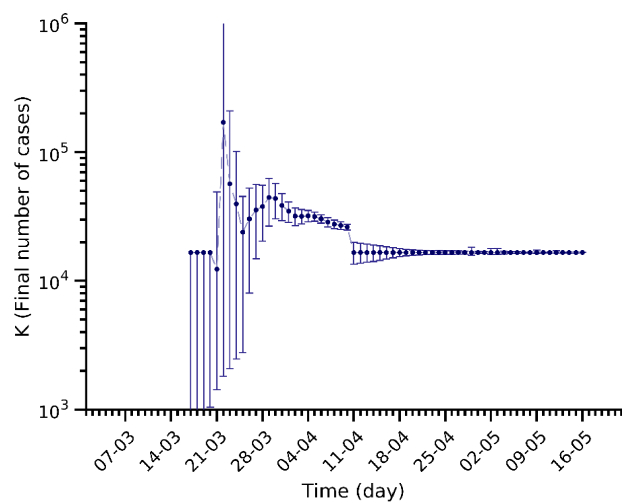
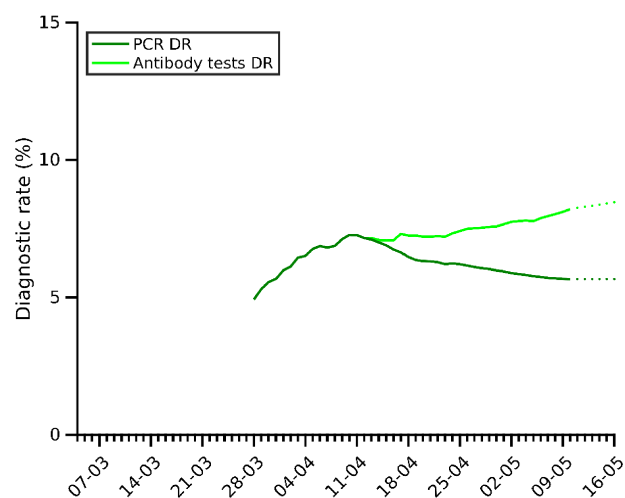
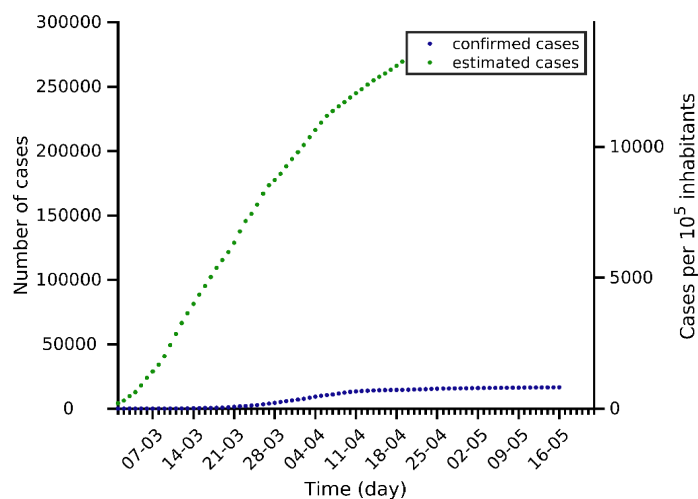
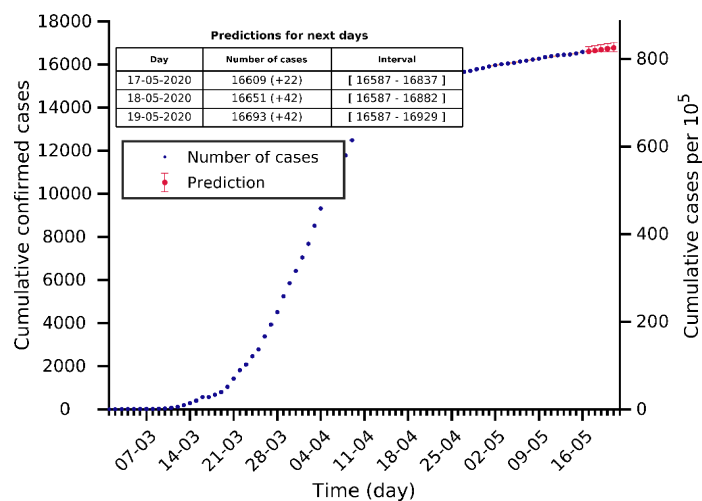
Catalunya 16-05-2020. Population: 7.7M. Current cumulated incidence: 691/10⁵



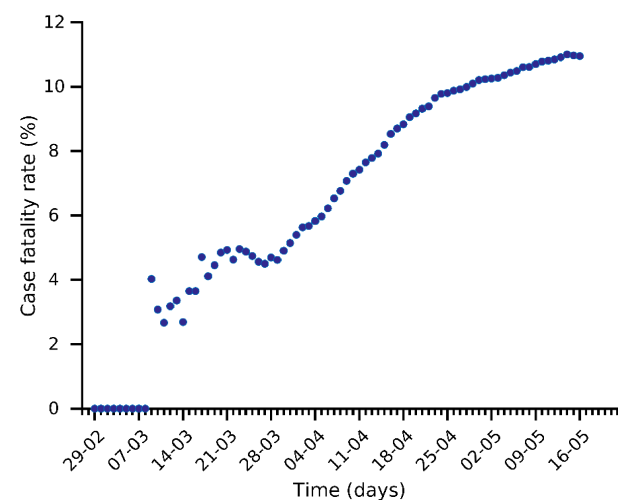
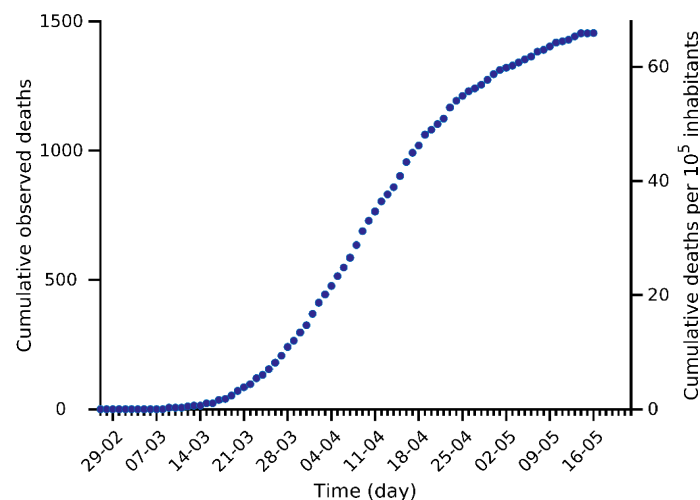
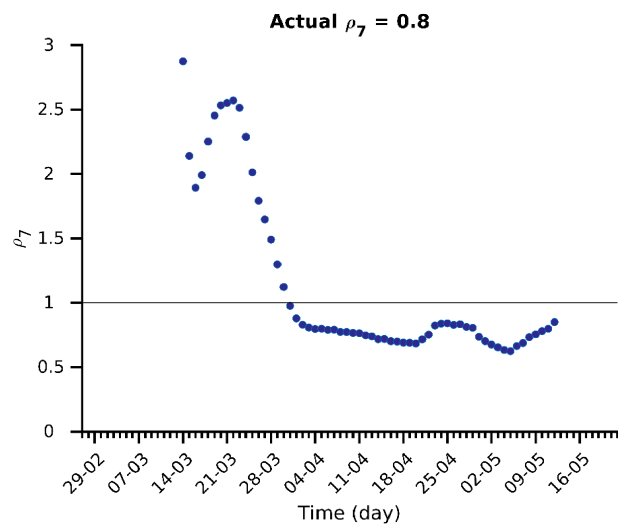
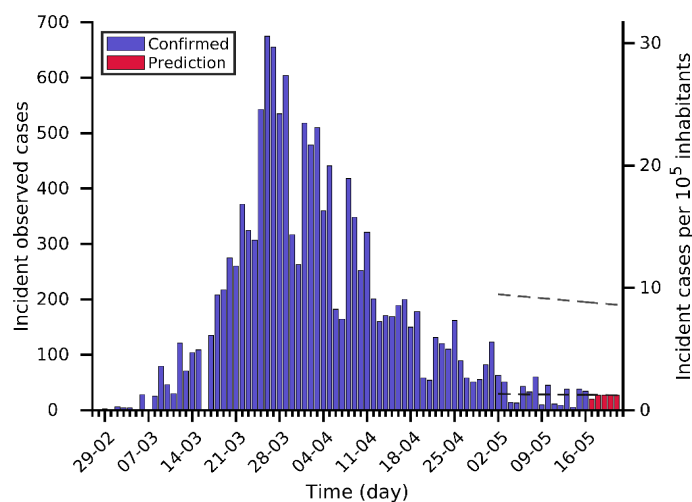
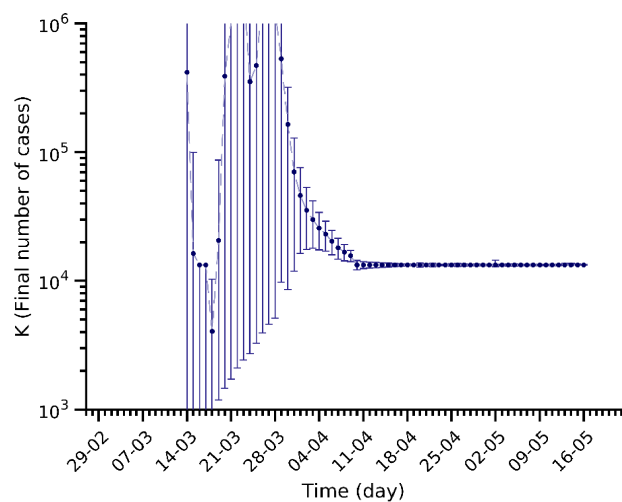
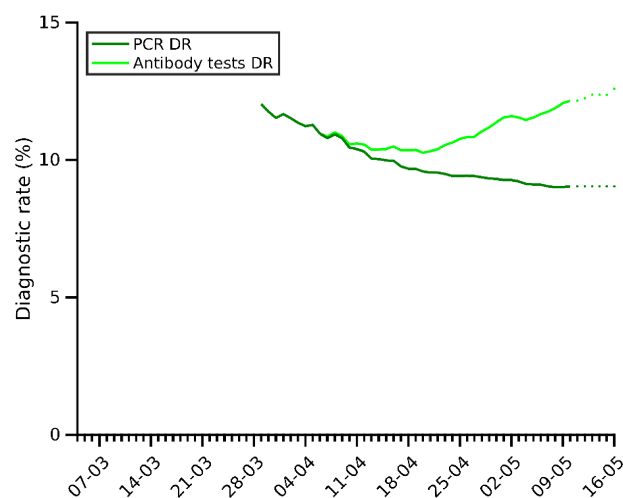
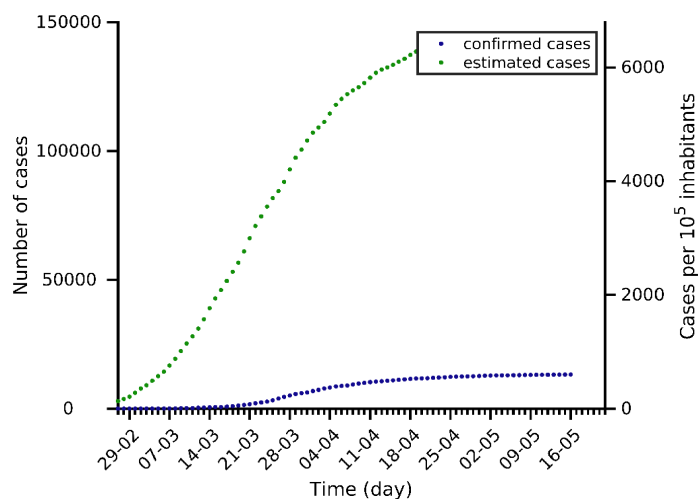
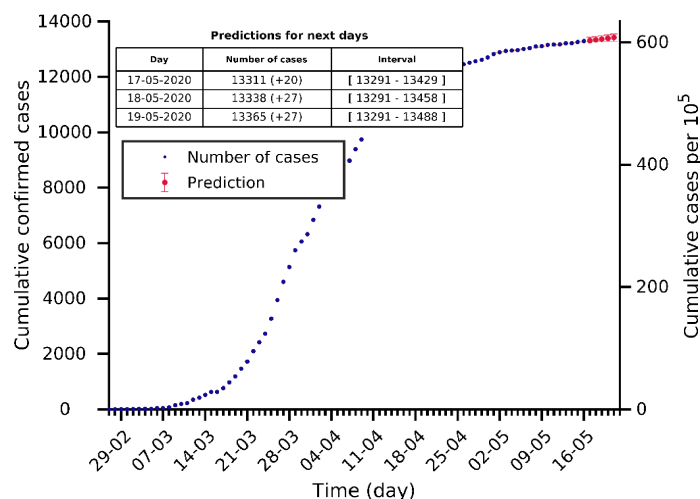
Castilla Leon 16-05-2020. Population: 2.4M. Current cumulated incidence: 766/10⁵



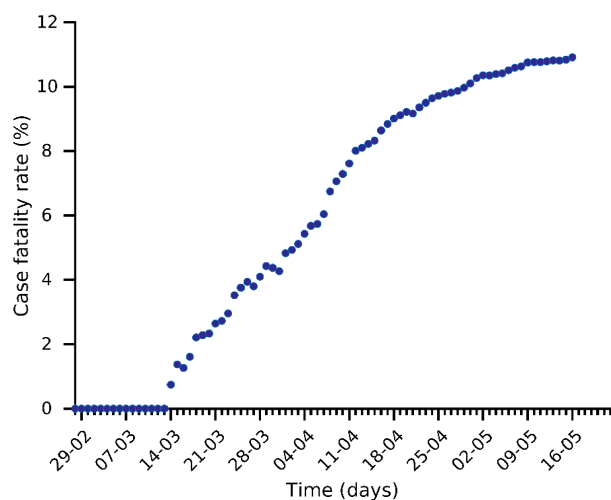
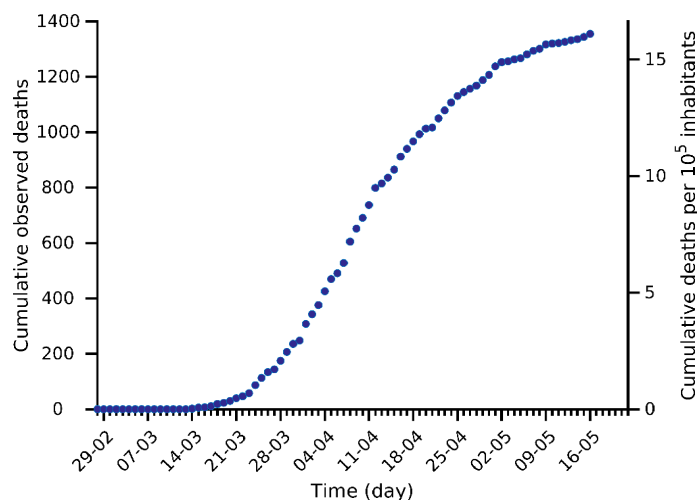
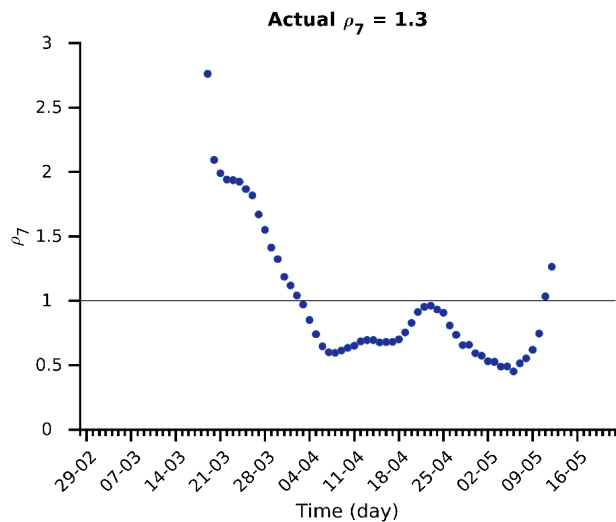
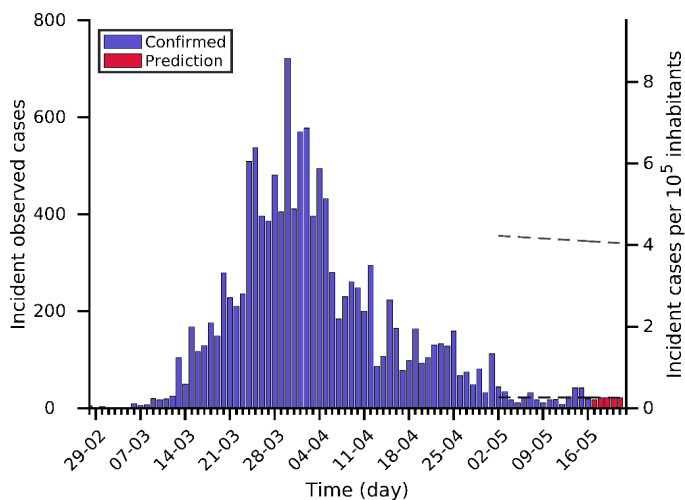
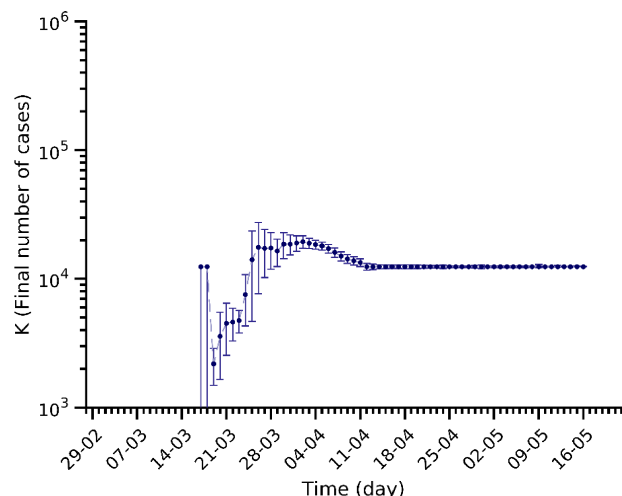
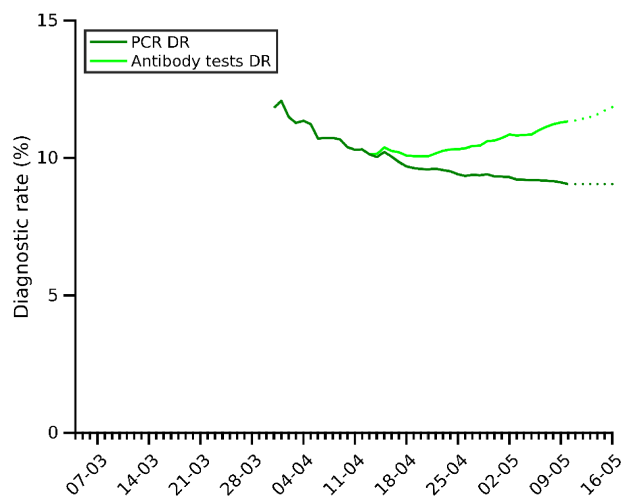
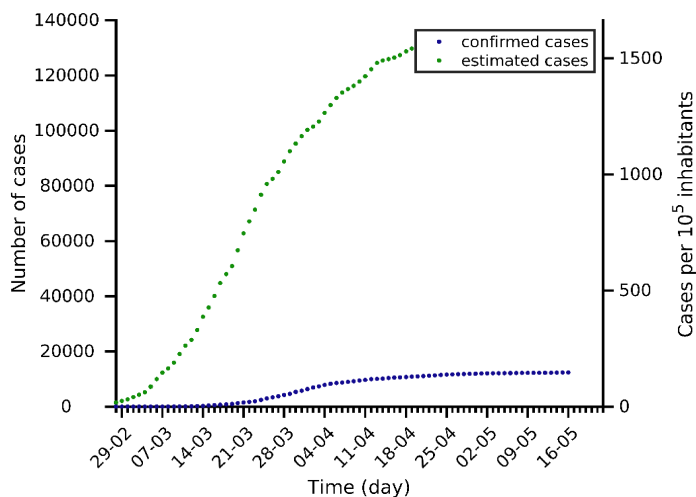
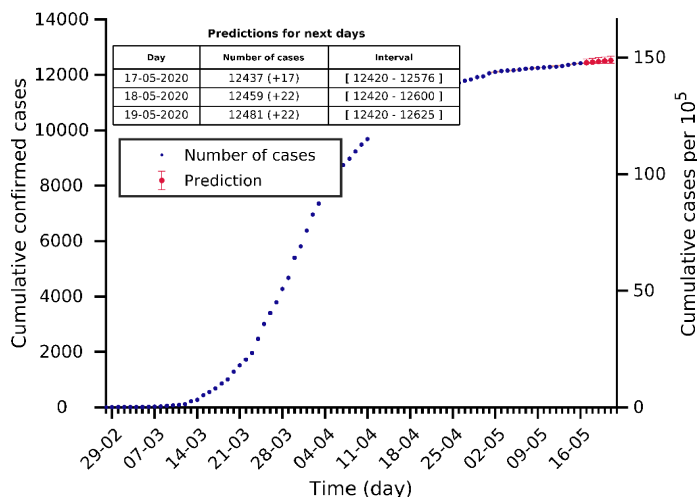
Castilla-La Mancha 16-05-2020. Population: 2.0M. Current cumulated incidence: 81



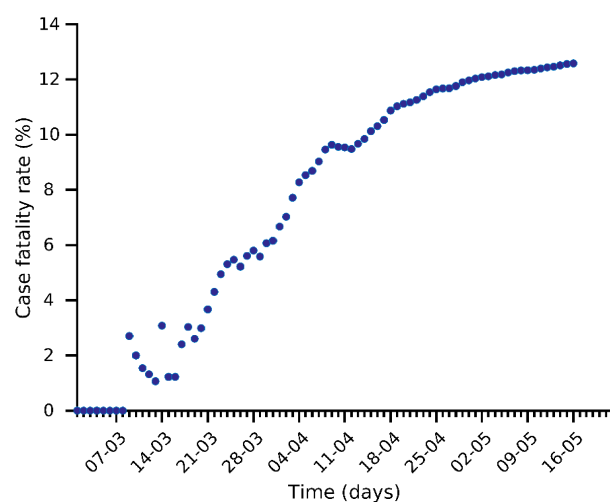
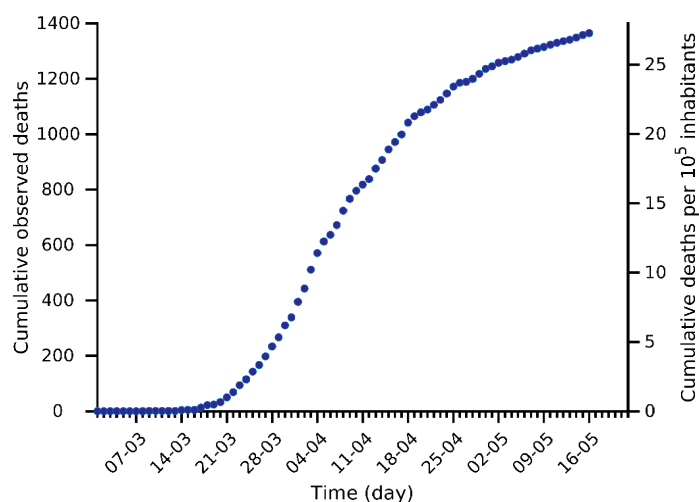
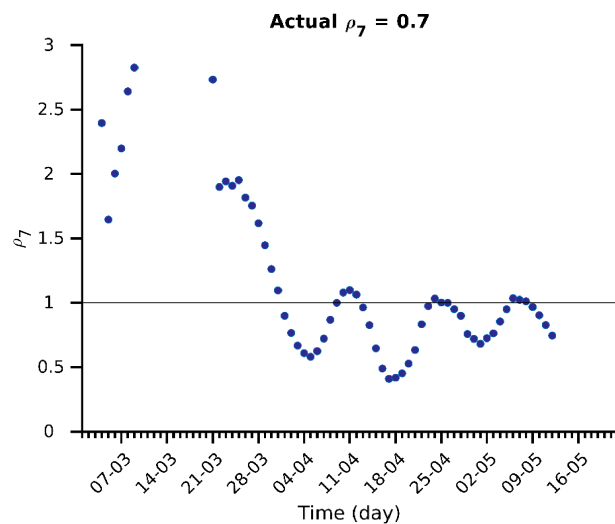
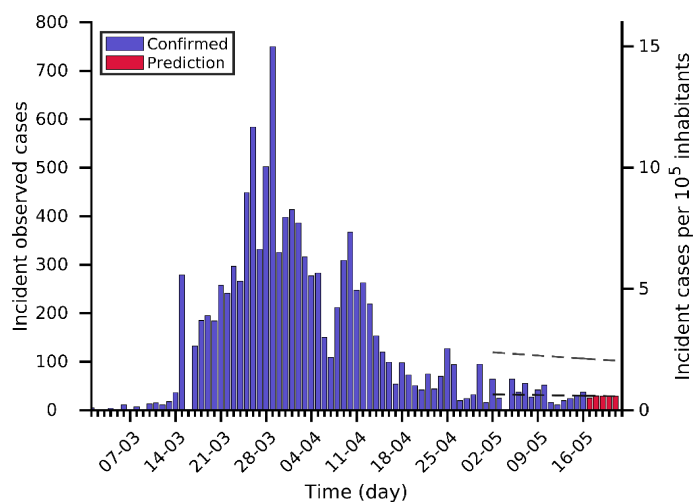
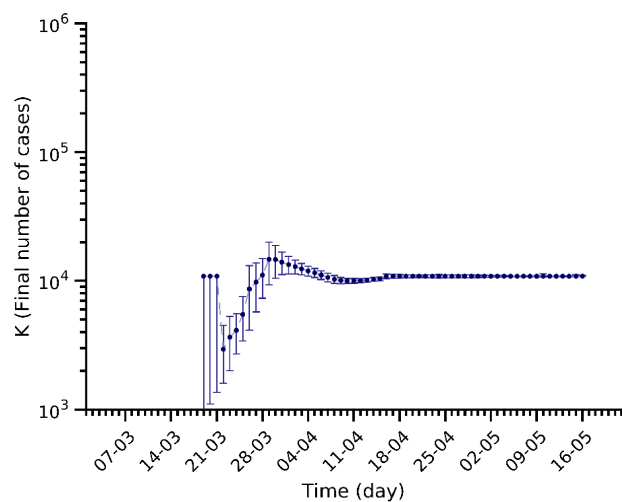
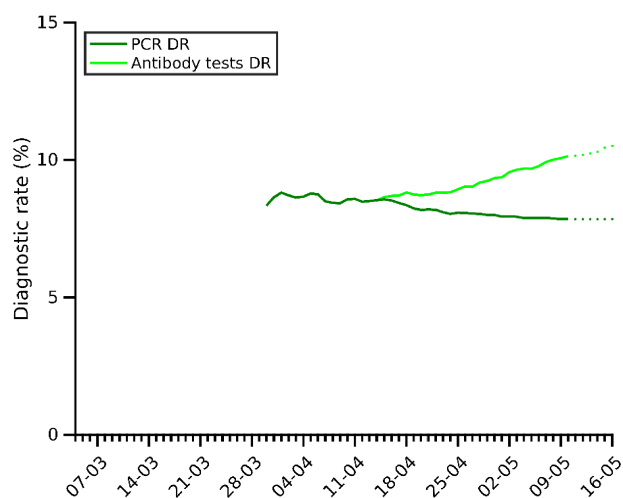
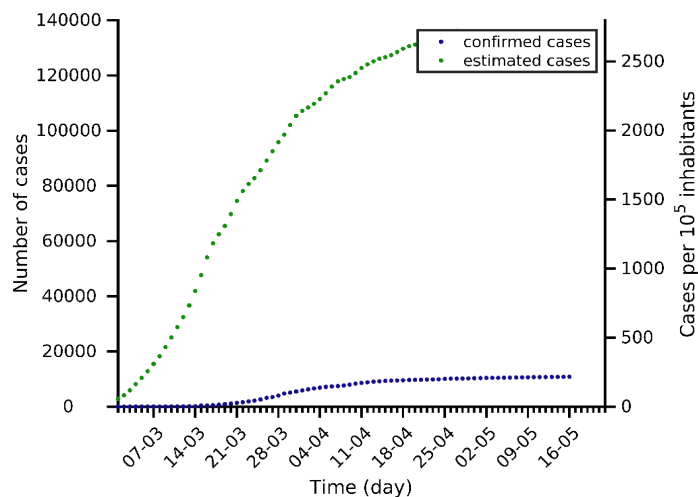
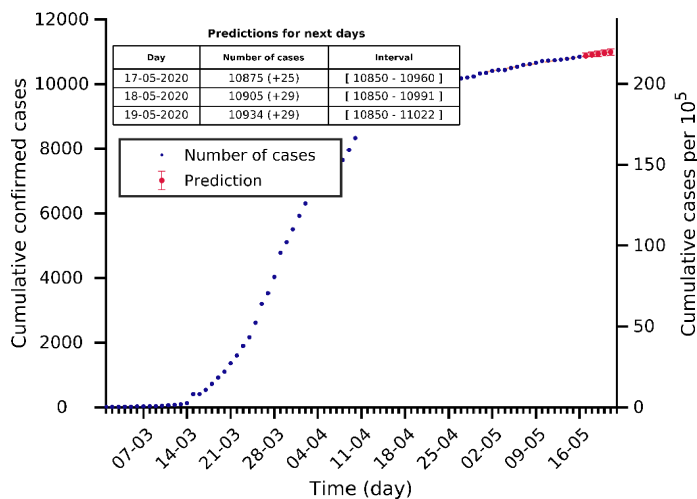
Euskadi 16-05-2020. Population: 2.2M. Current cumulated incidence: 602/10⁵



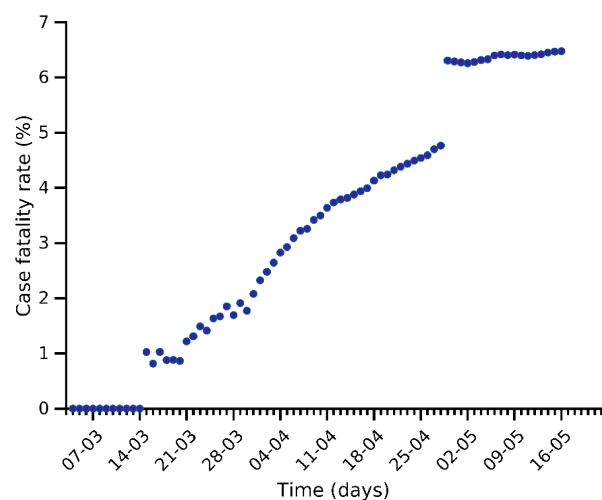
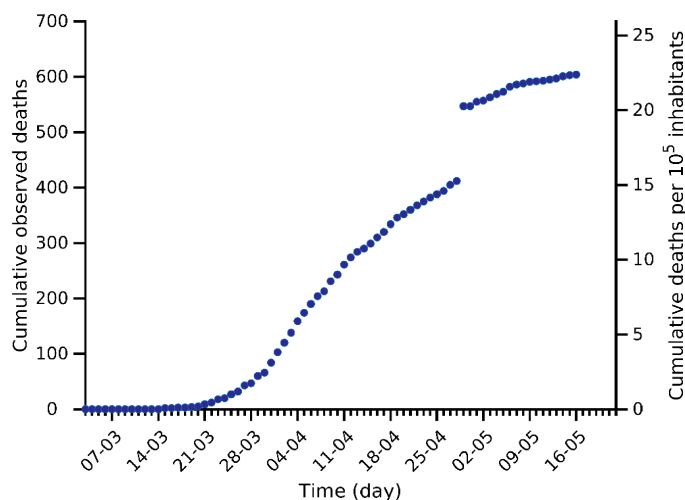
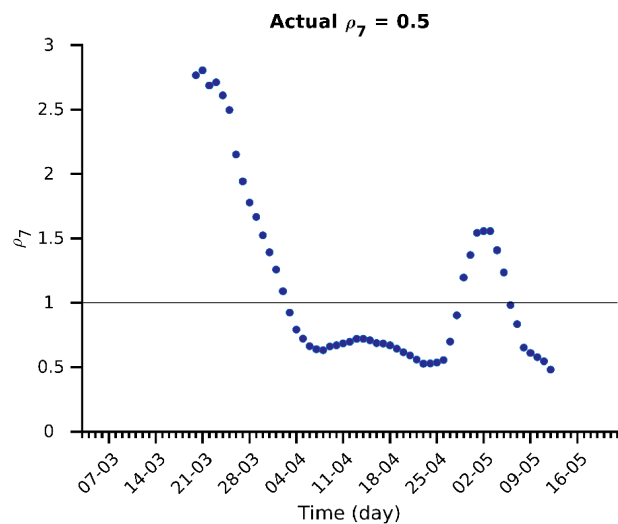
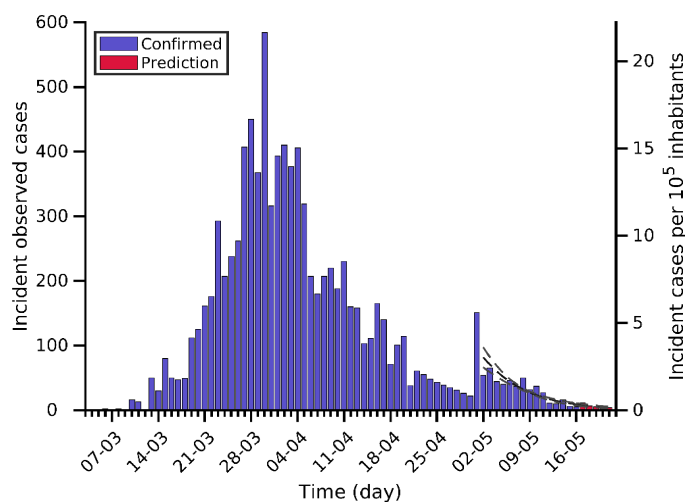
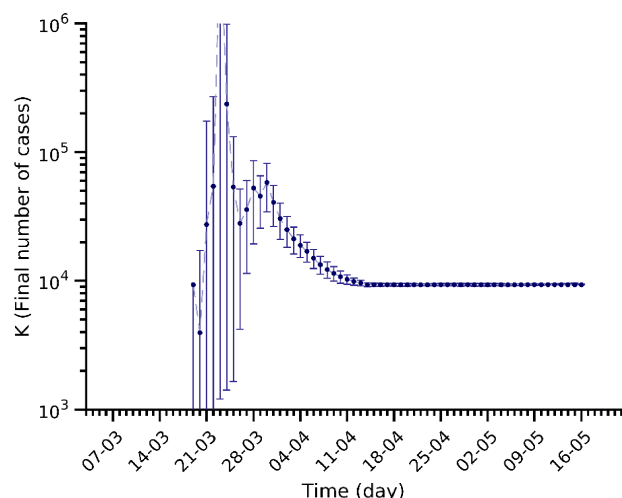
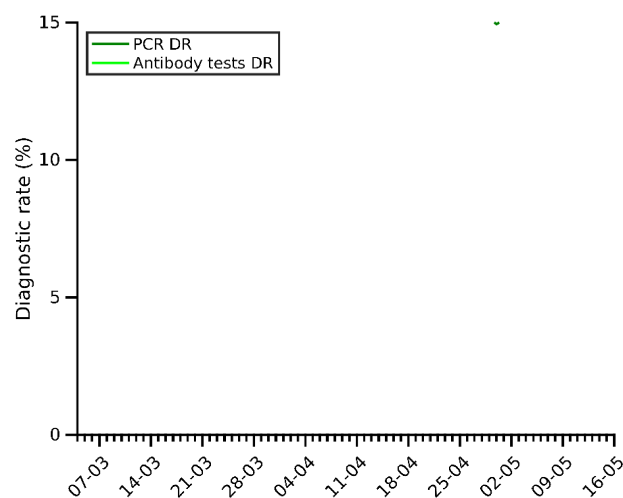
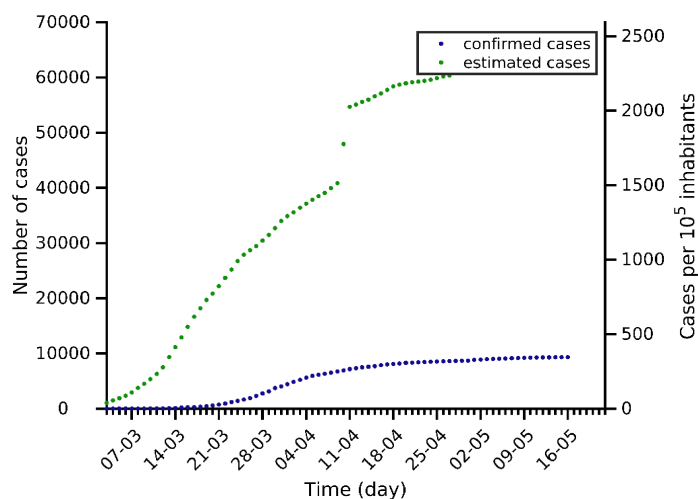
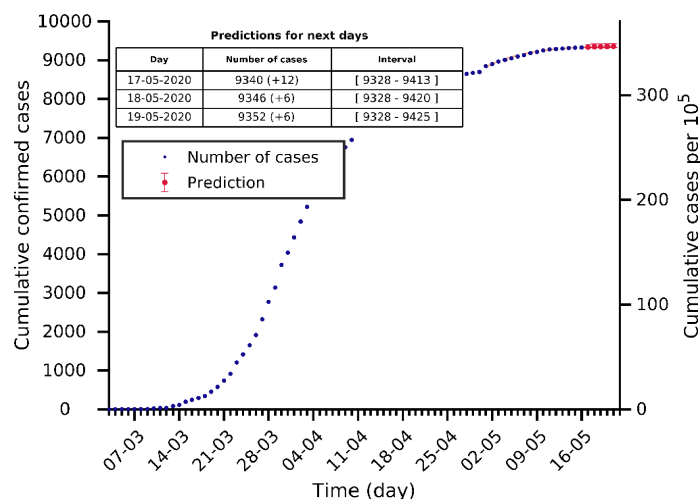
Andalucia 16-05-2020. Population: 8.4M. Current cumulated incidence: 148/10⁵



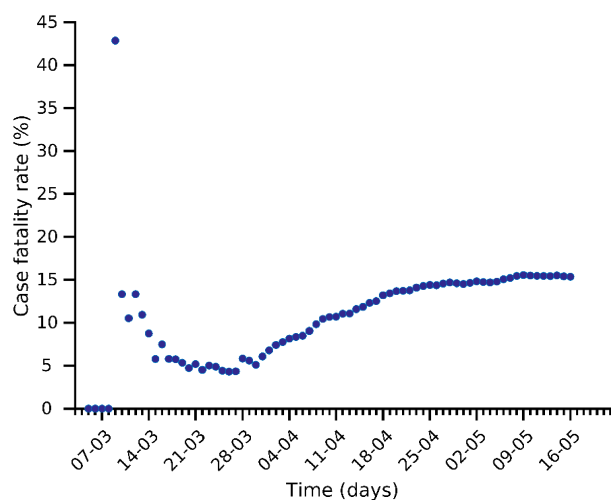
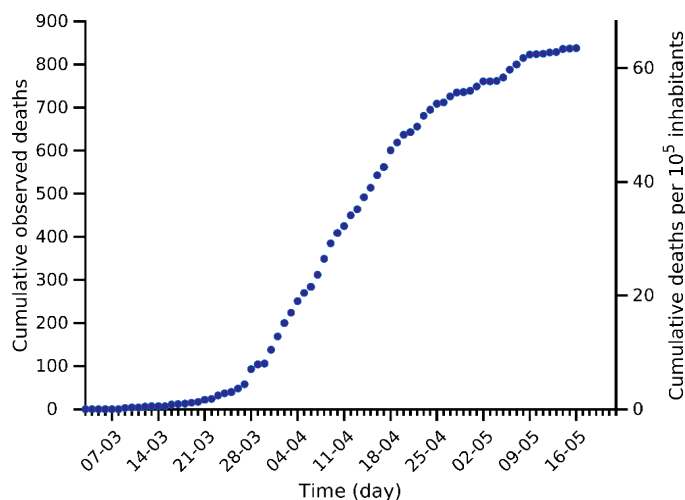
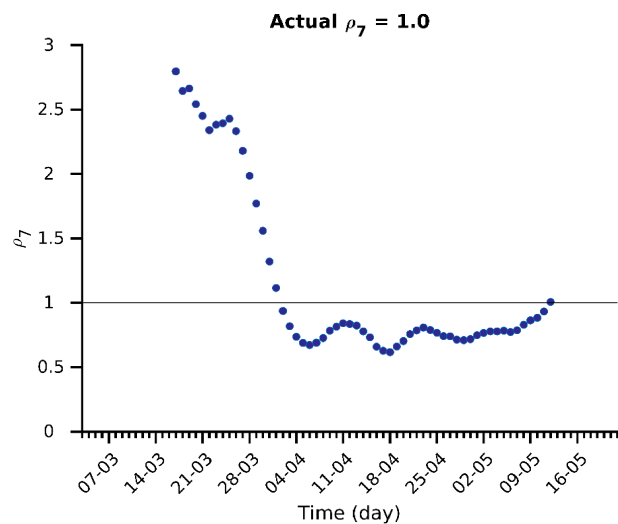
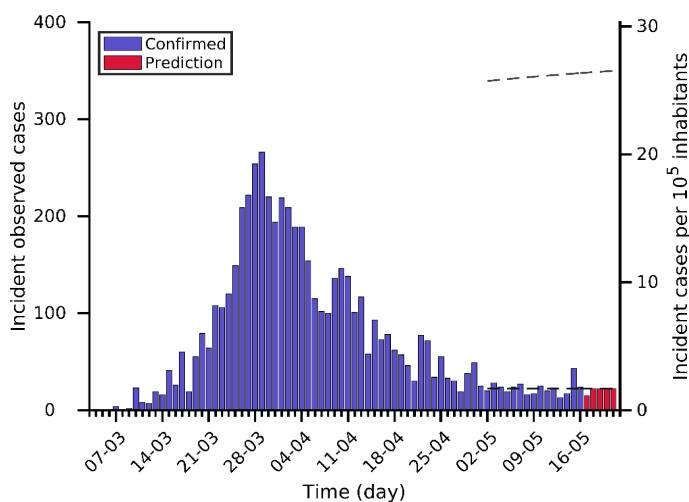
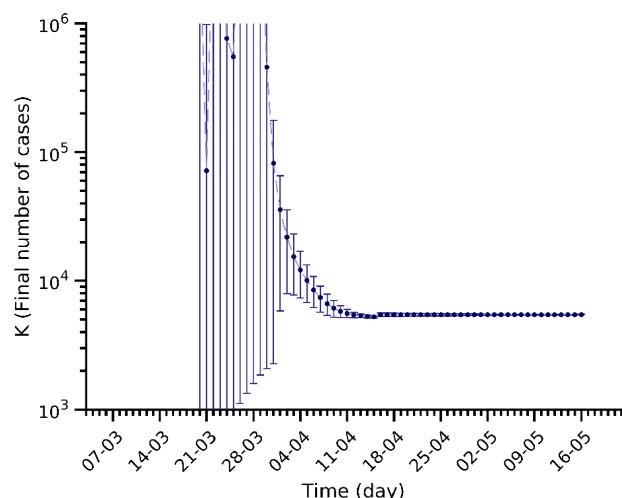
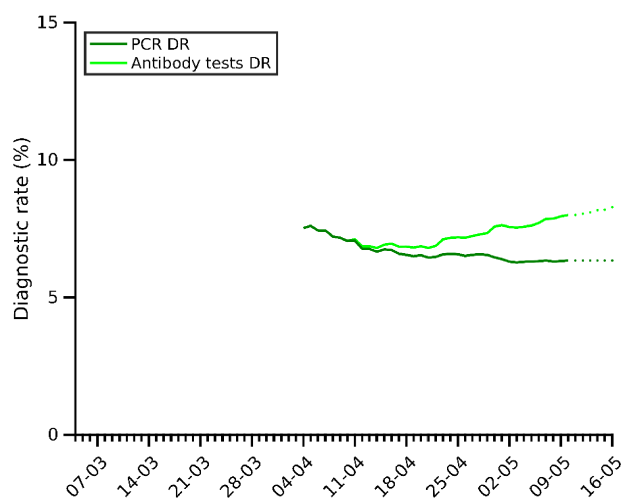
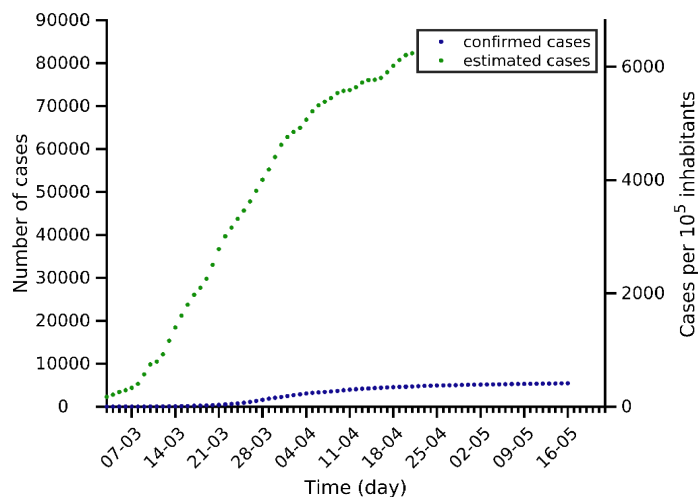
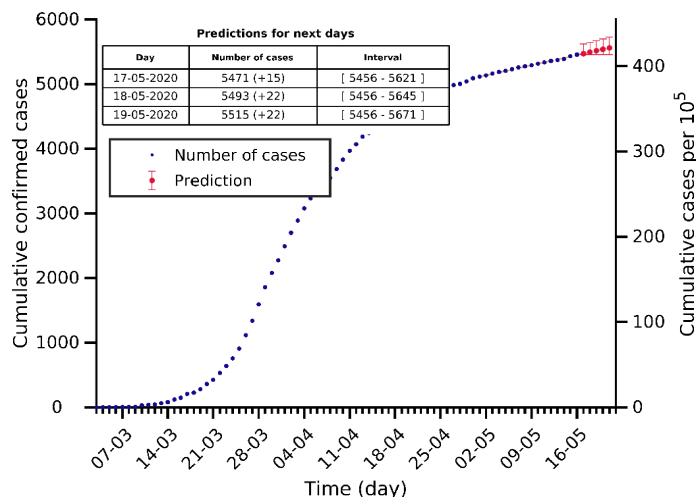
C Valenciana 16-05-2020. Population: 5.0M. Current cumulated incidence: 217/10⁵



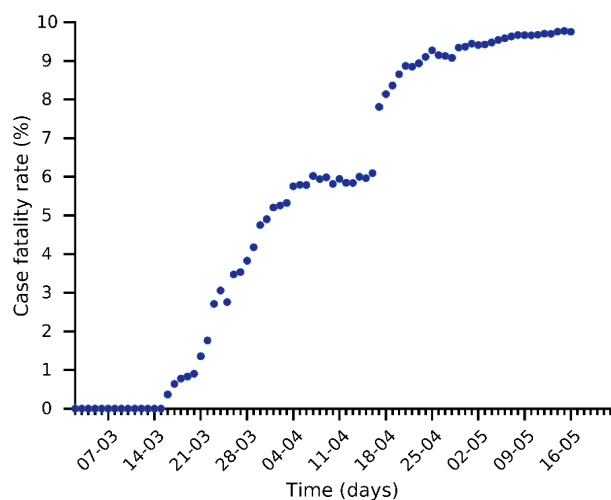
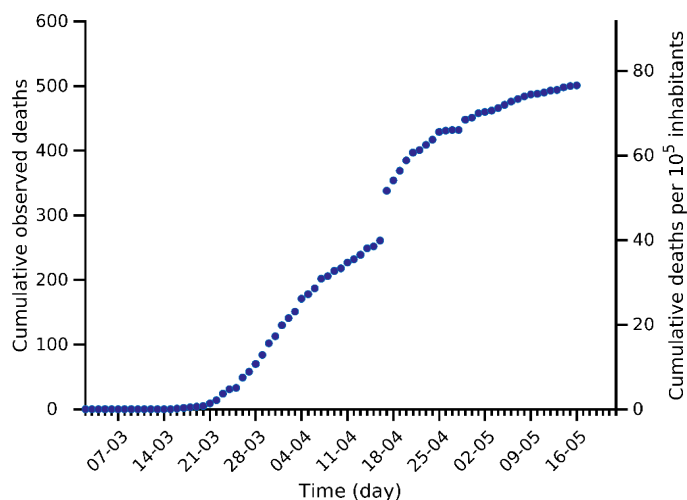
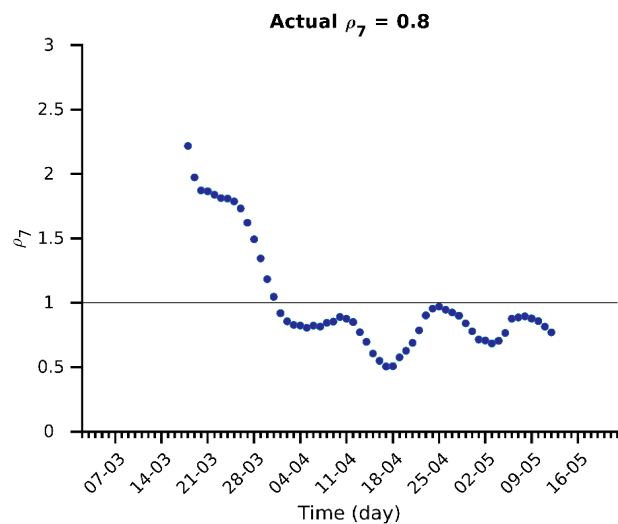
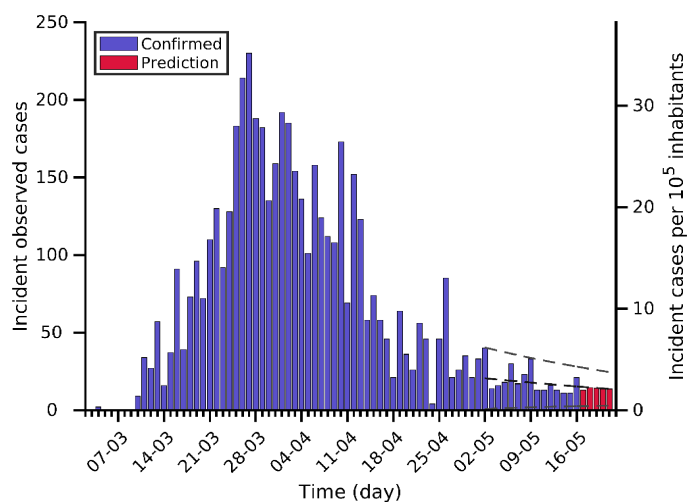
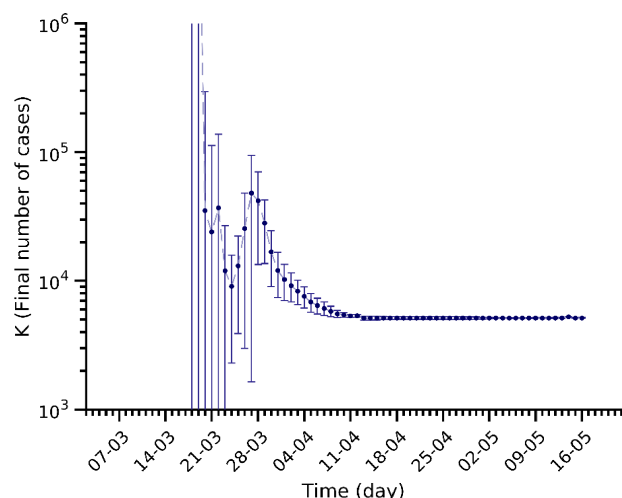
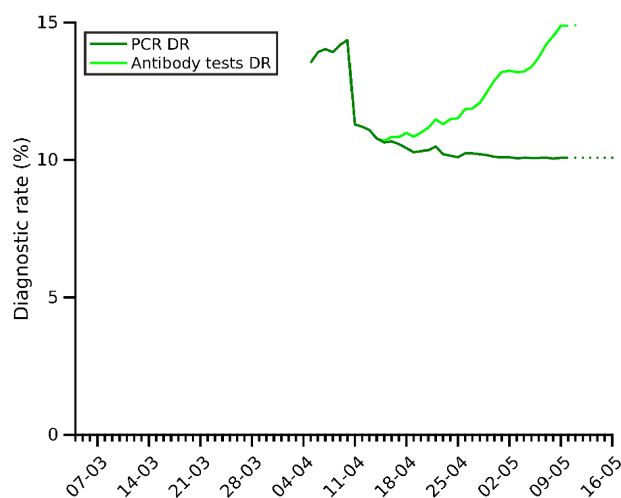
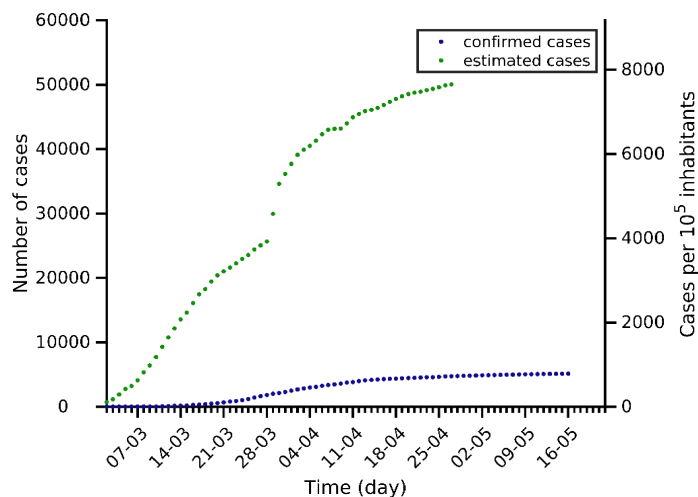
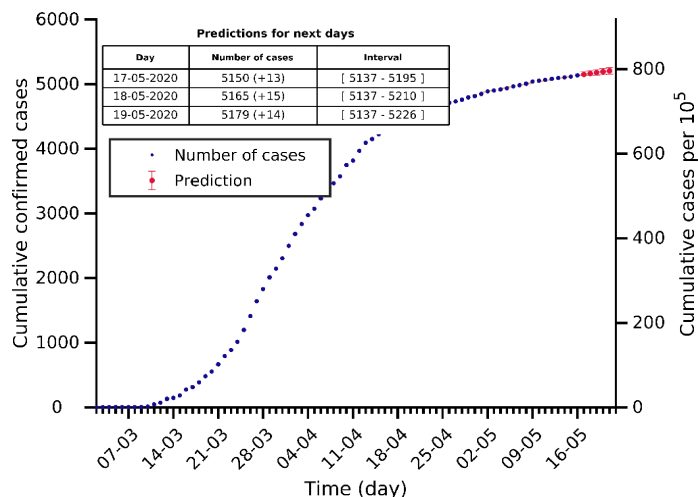
Galicia 16-05-2020. Population: 2.7M. Current cumulated incidence: 346/10⁵



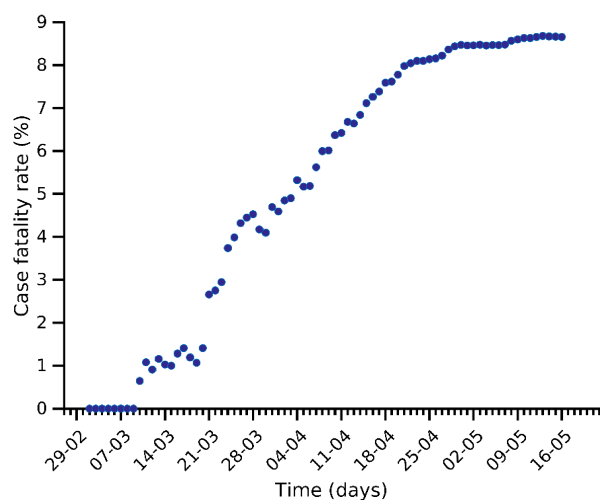
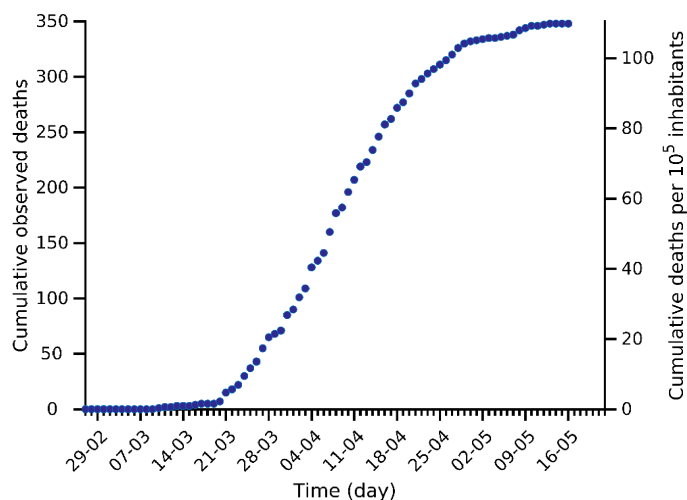
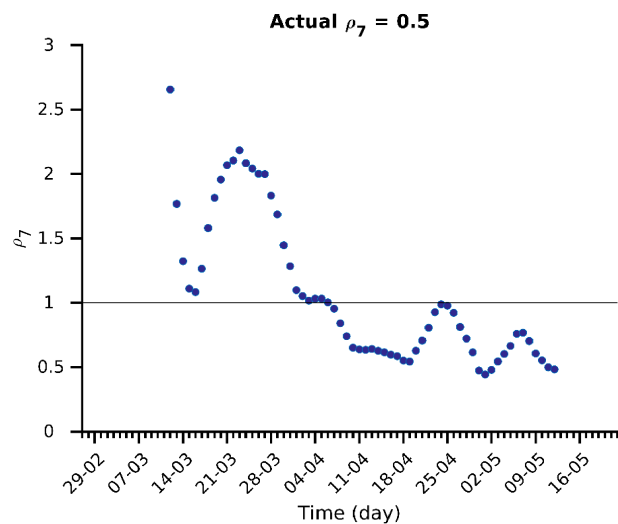
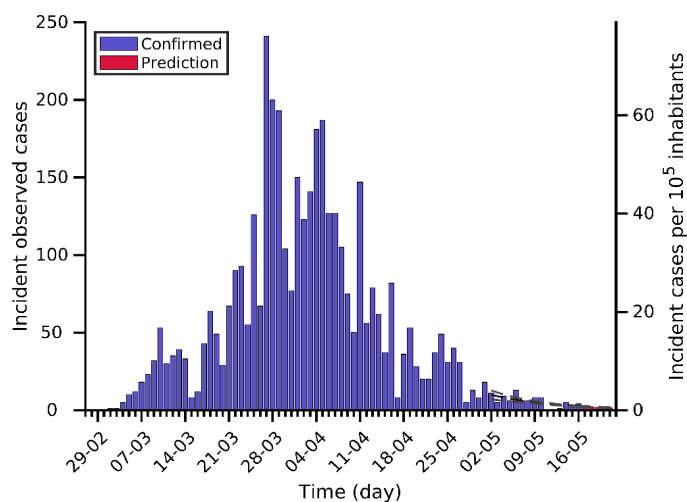
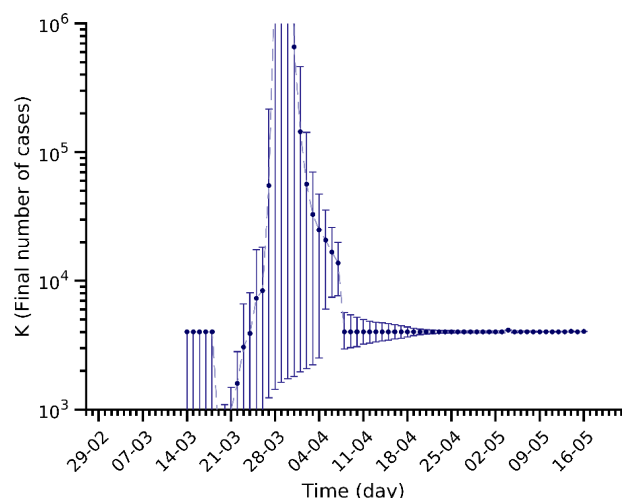
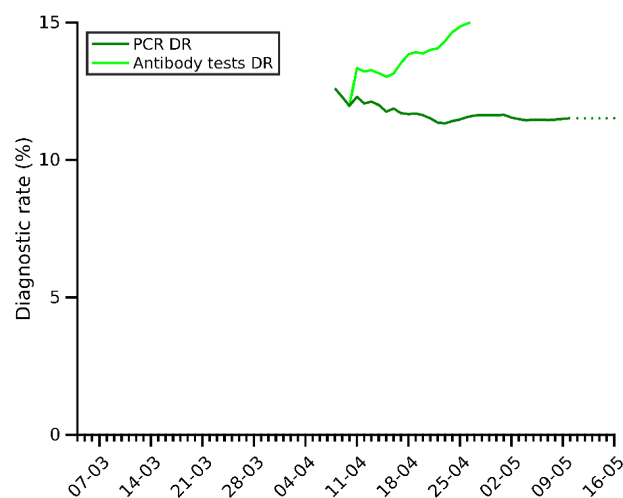
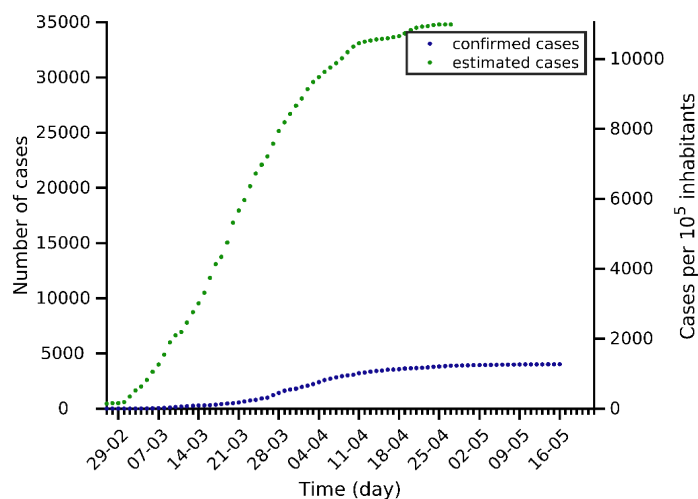
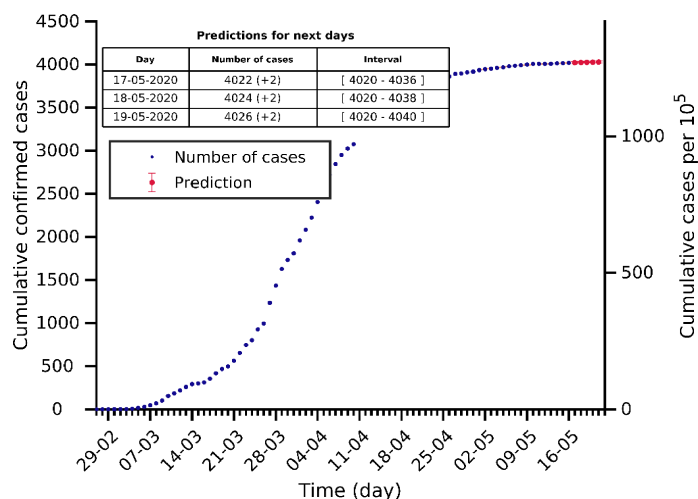
Aragon 16-05-2020. Population: 1.3M. Current cumulated incidence: 414/10⁵



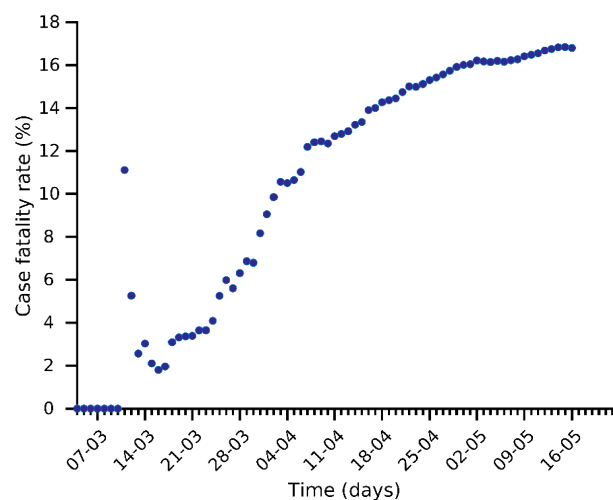
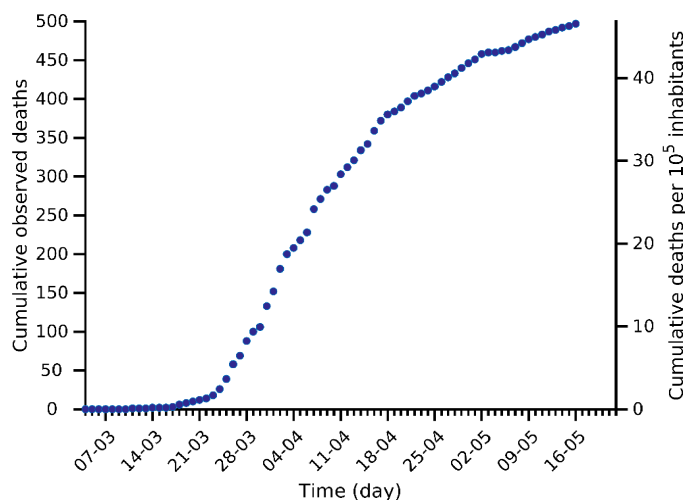
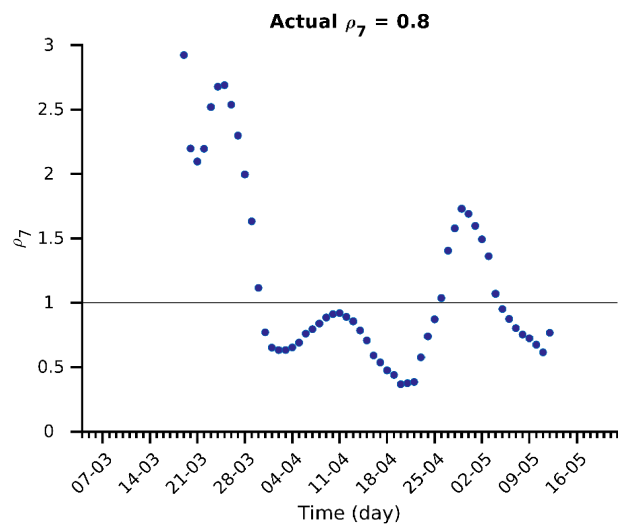
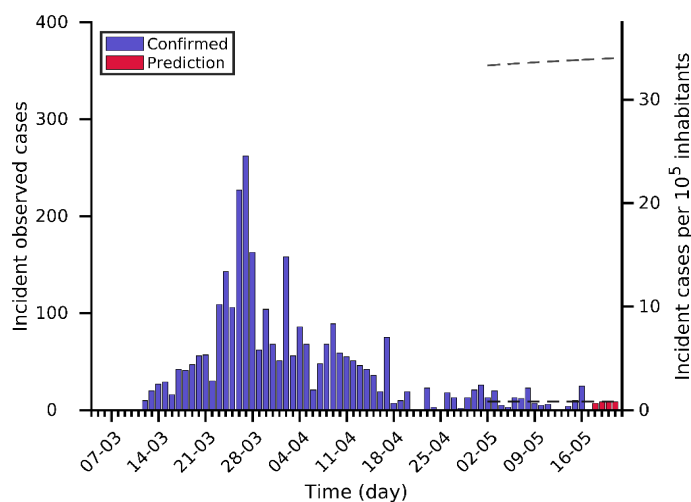
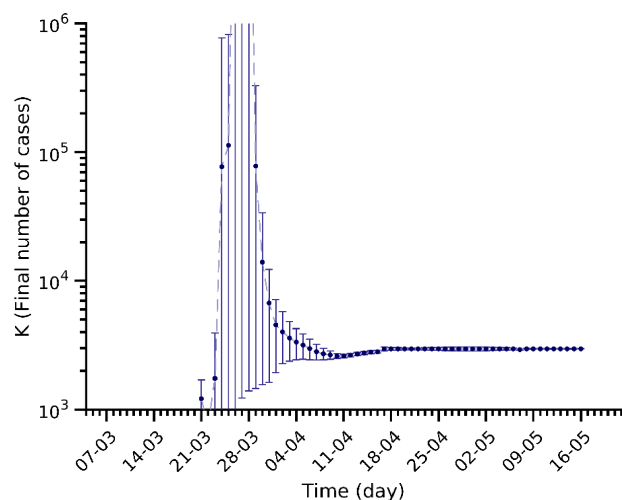
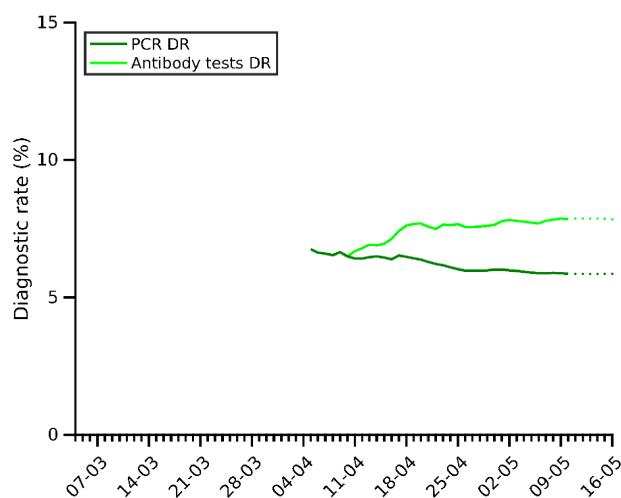
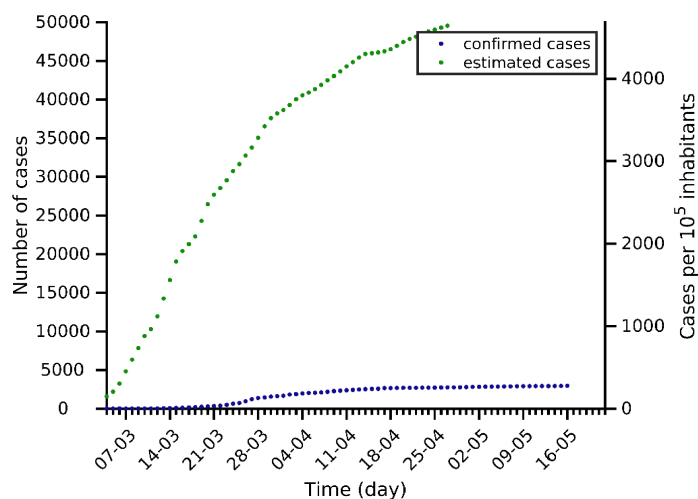
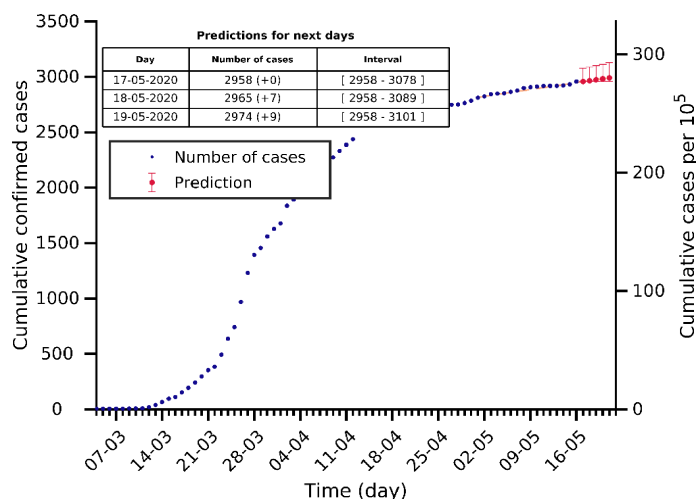
Navarra 16-05-2020. Population: 0.7M. Current cumulated incidence: 785/10⁵



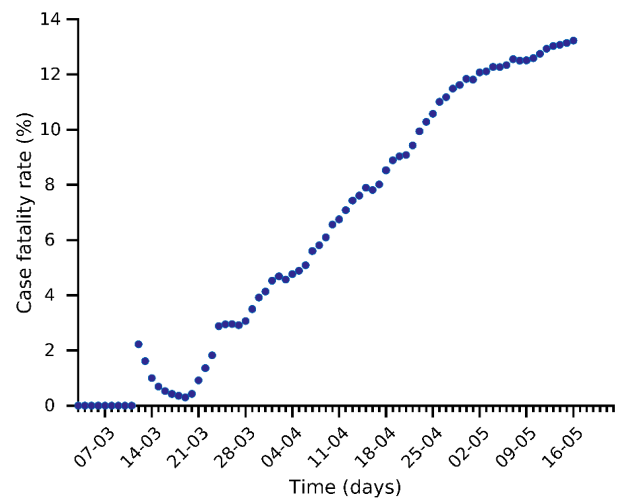
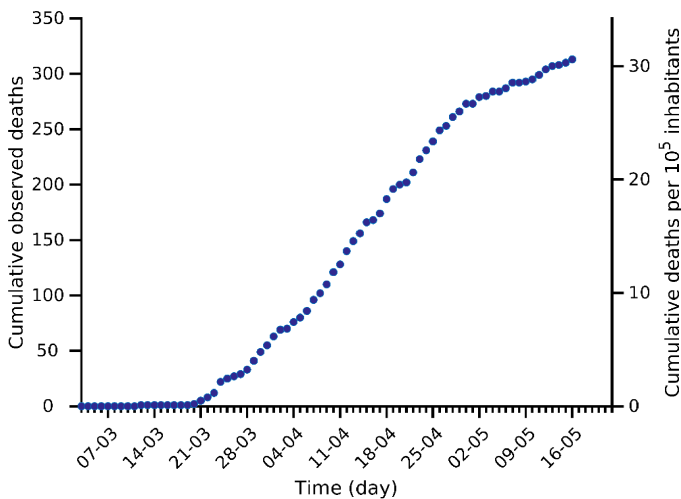
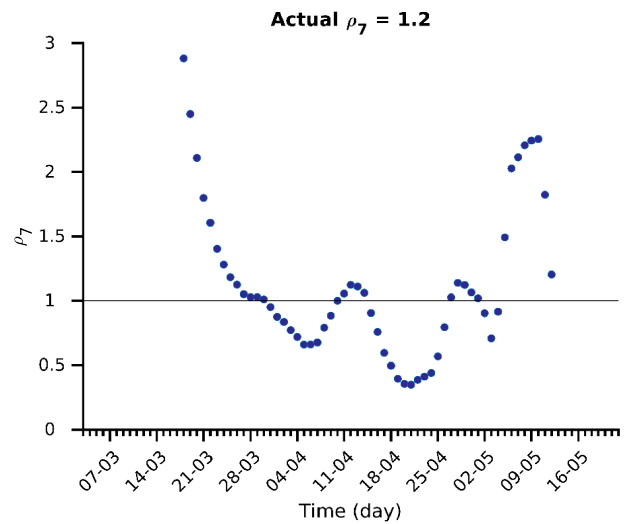
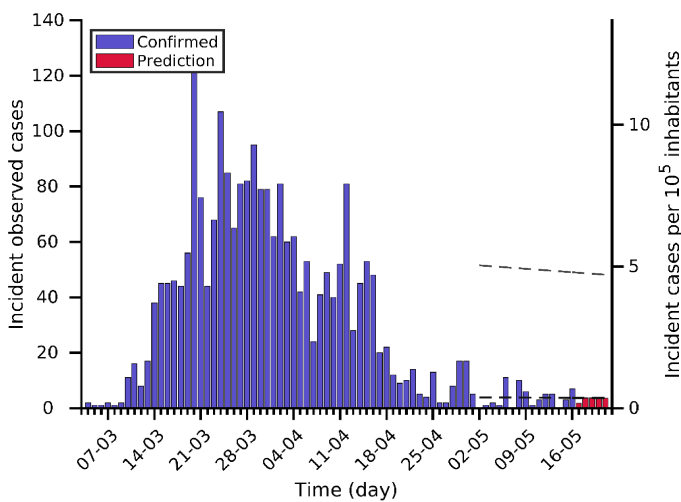
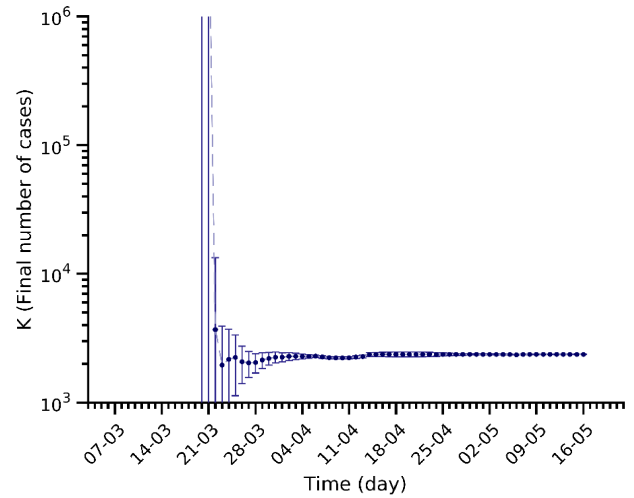
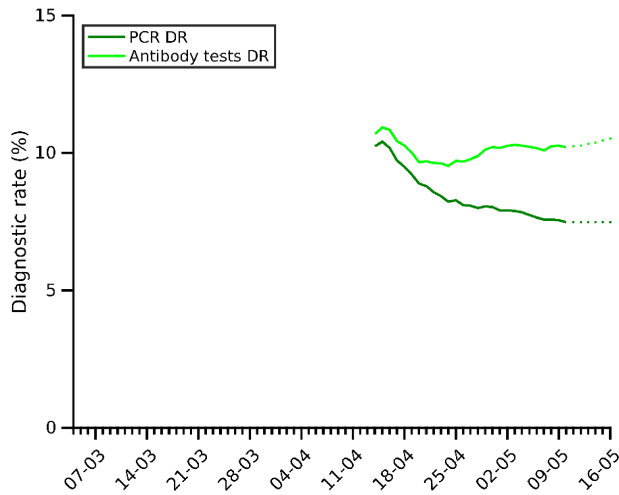
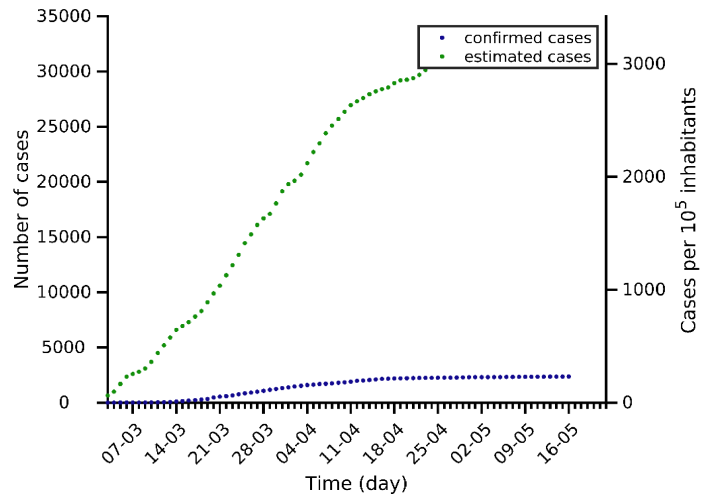
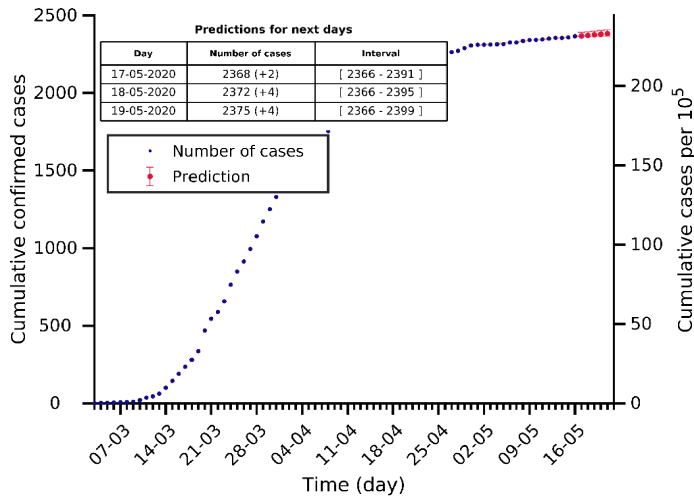
La Rioja 16-05-2020. Population: 0.3M. Current cumulated incidence: 1269/10⁵



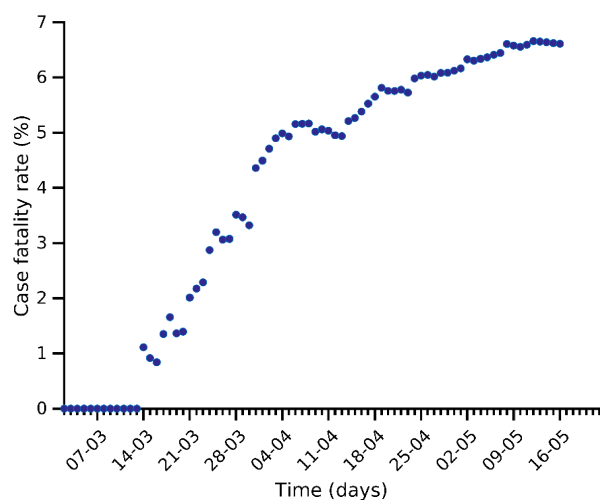
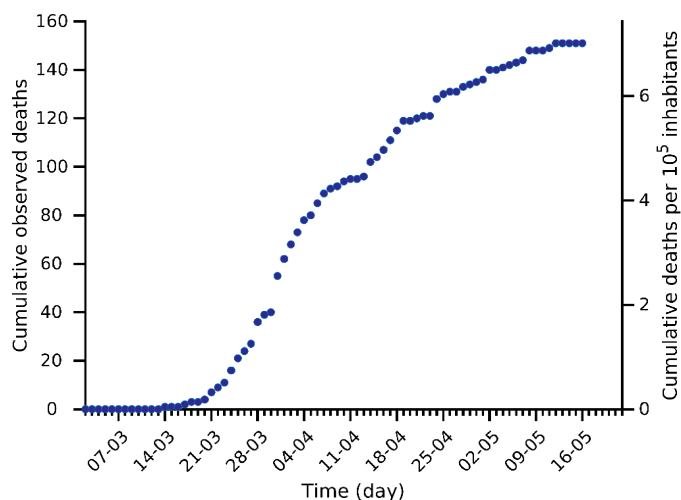
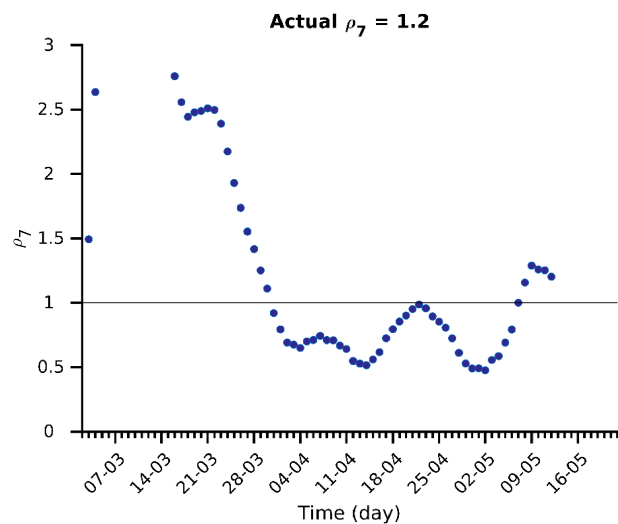
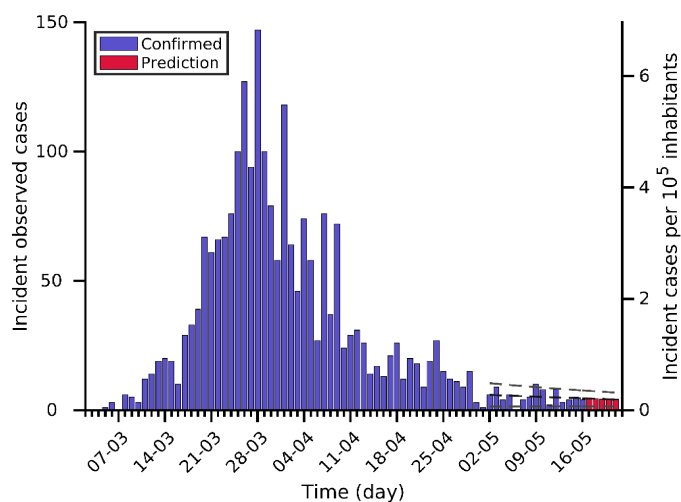
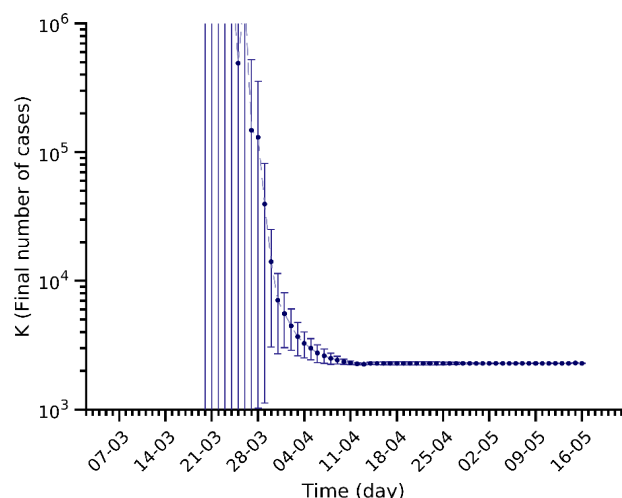
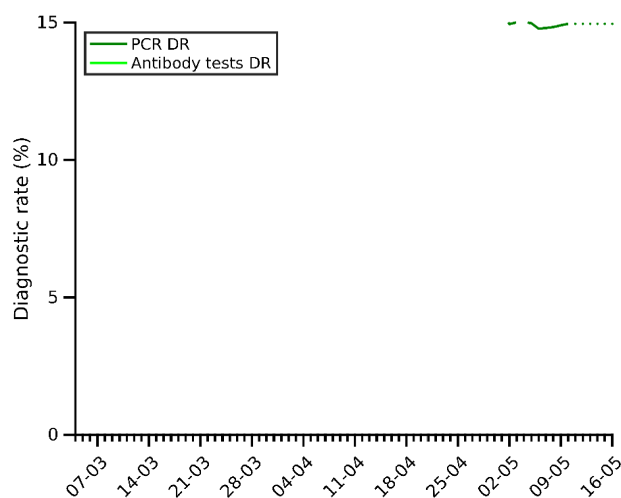
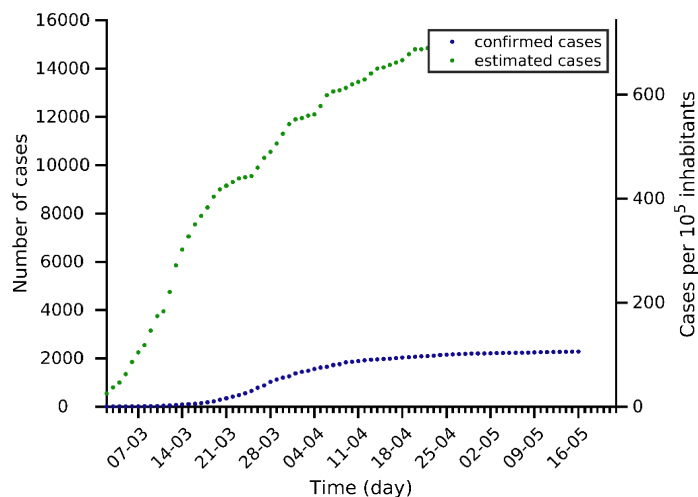
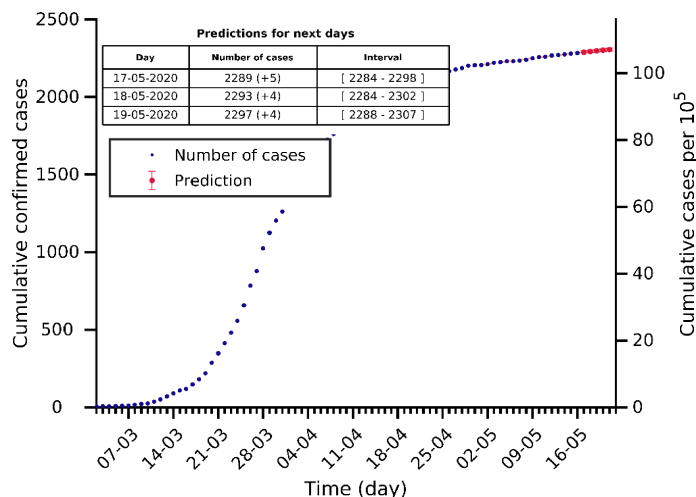
Extremadura 16-05-2020. Population: 1.1M. Current cumulated incidence: 277/10⁵



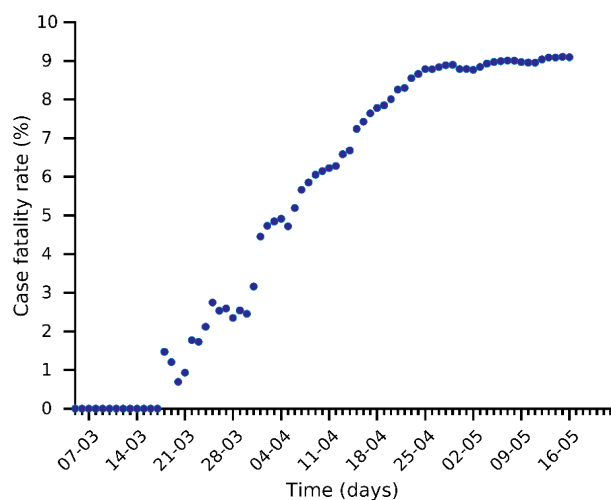
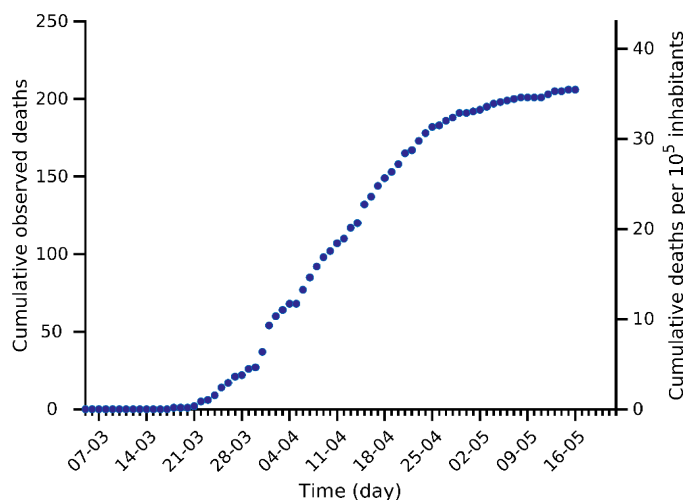
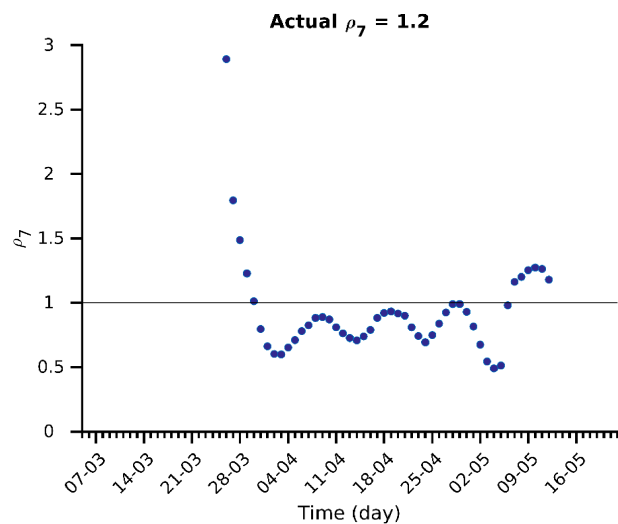
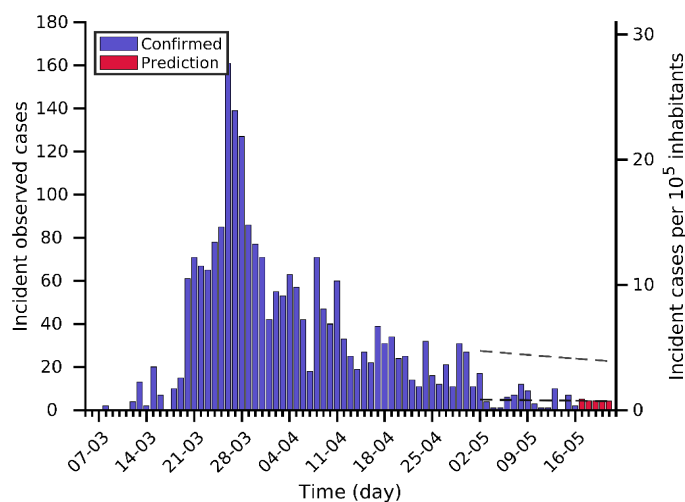
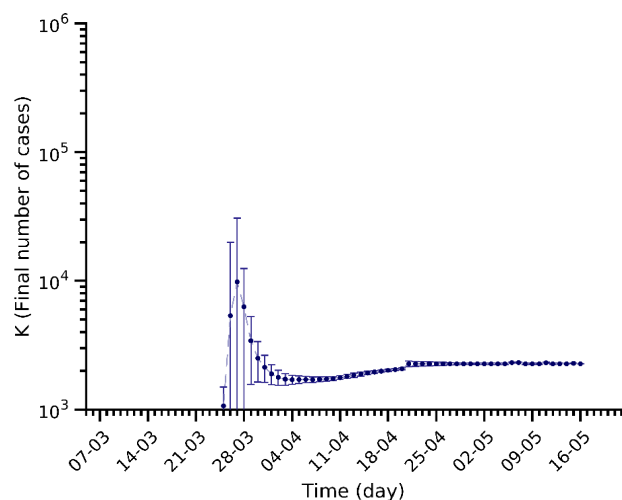
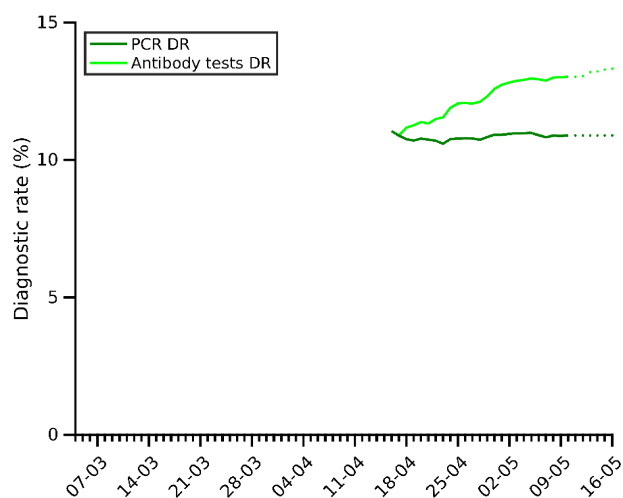
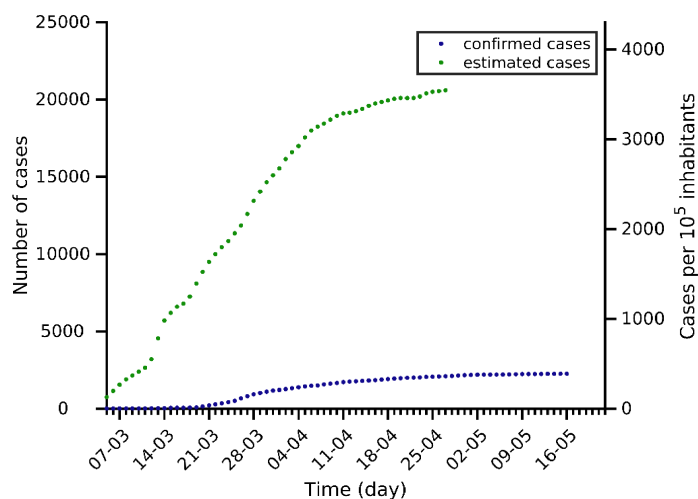
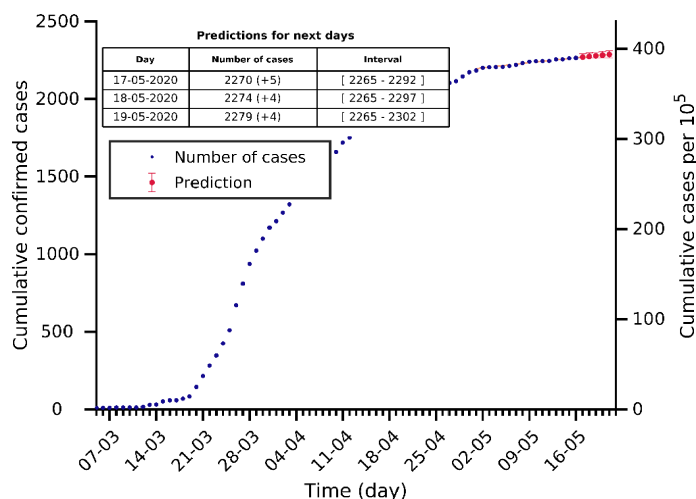
Asturias 16-05-2020. Population: 1.0M. Current cumulated incidence: 231/10⁵



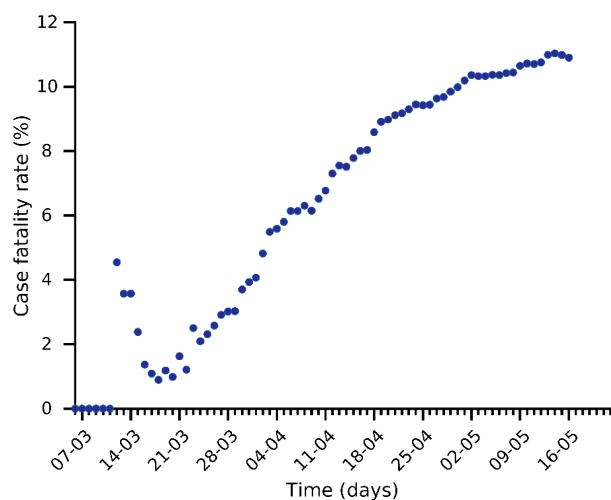
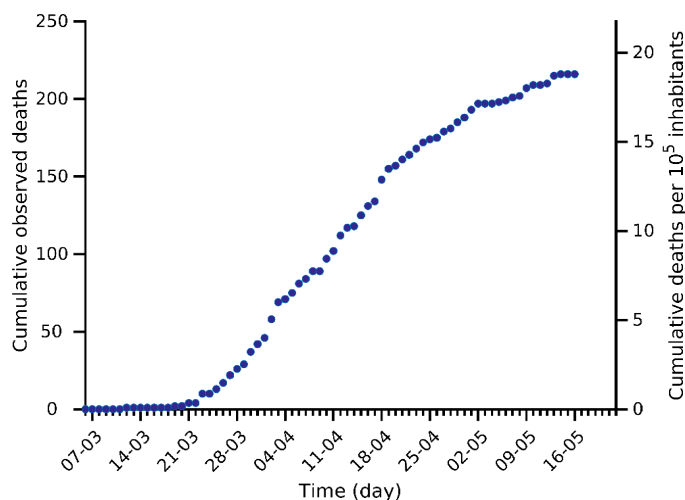
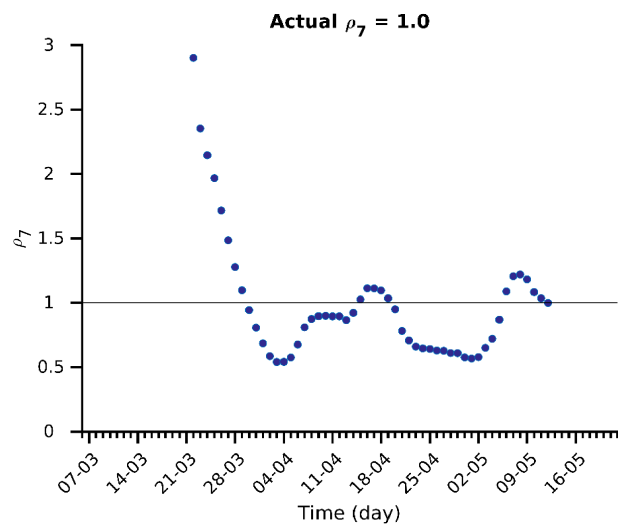
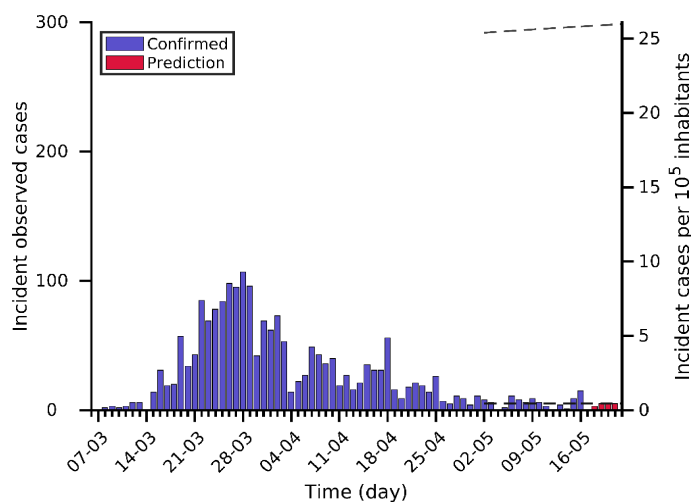
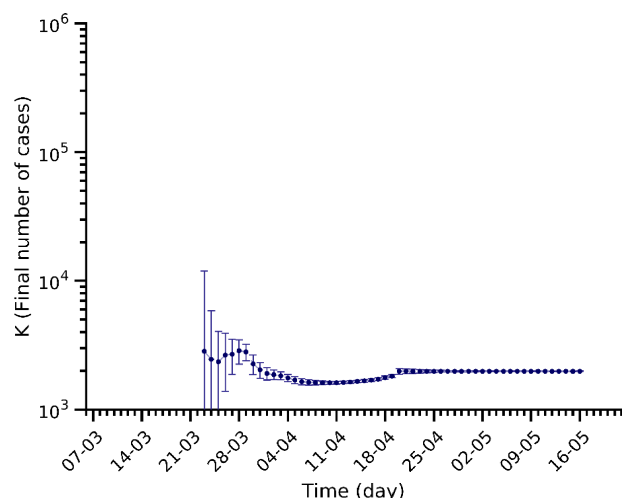
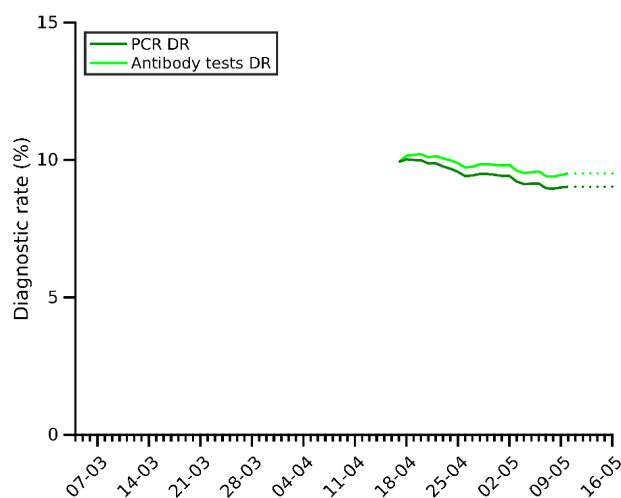
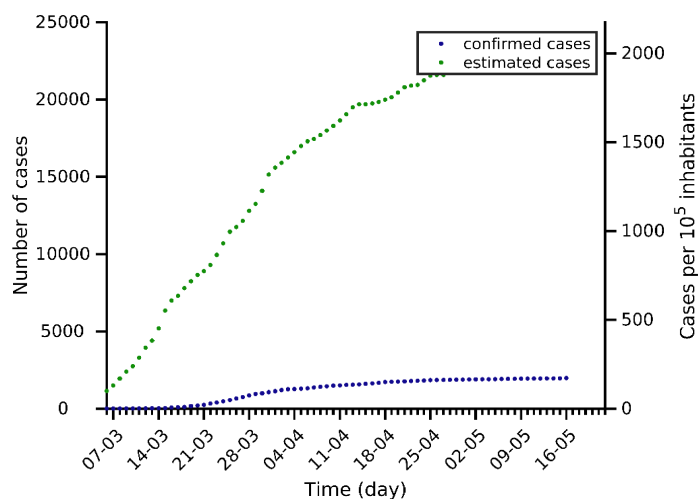
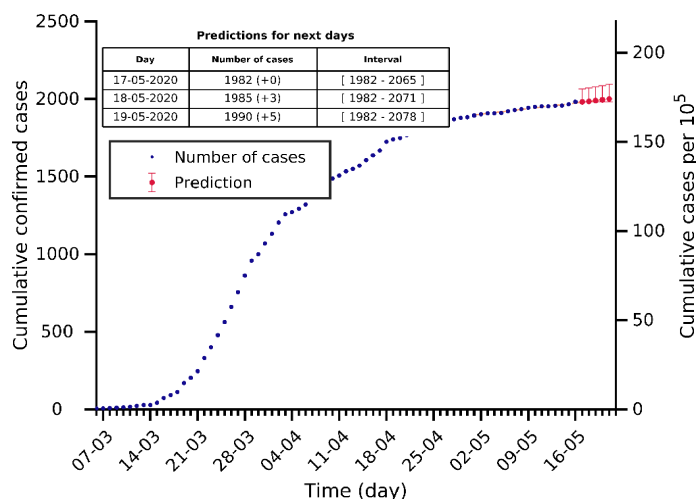
Canarias 16-05-2020. Population: 2.2M. Current cumulated incidence: 106/10⁵



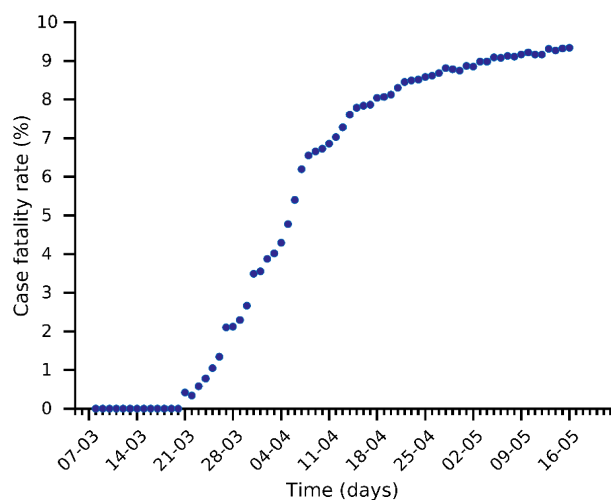
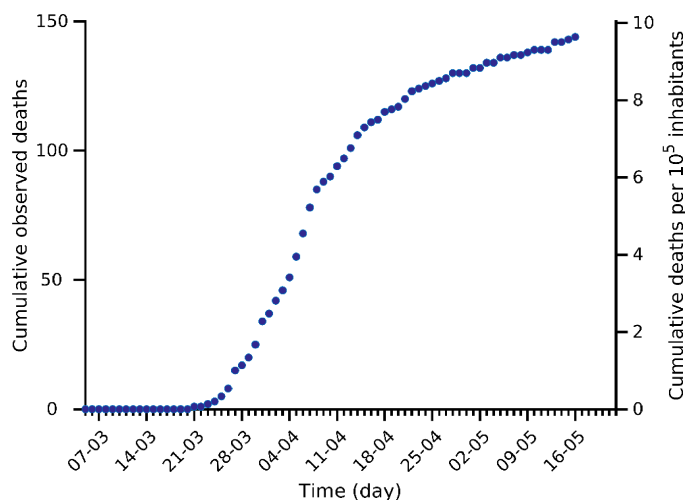
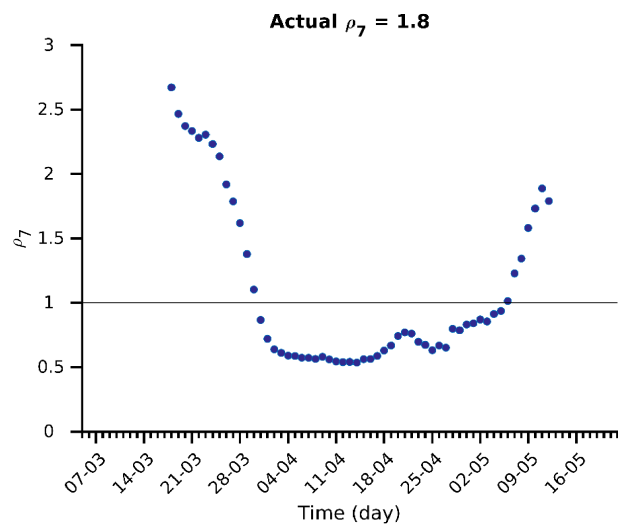
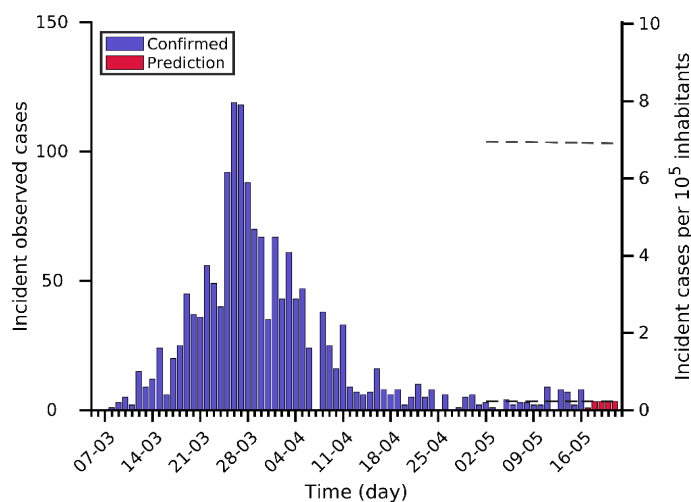
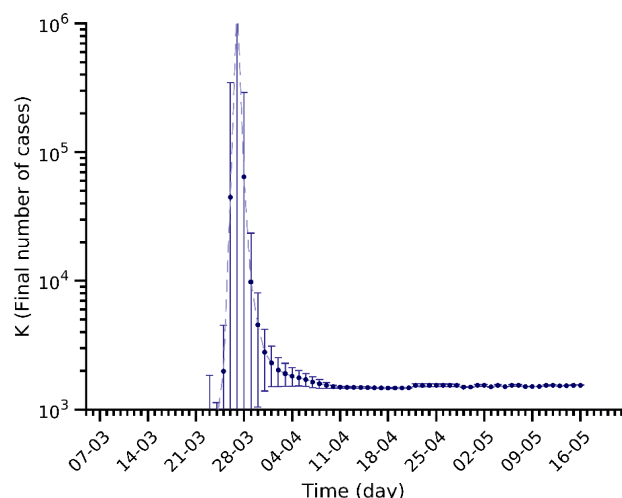
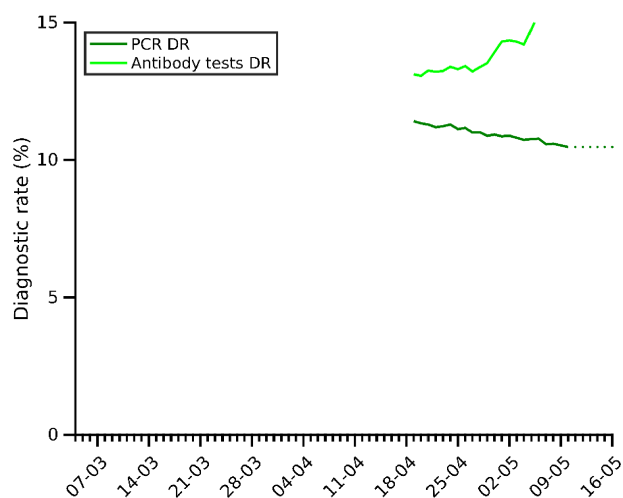
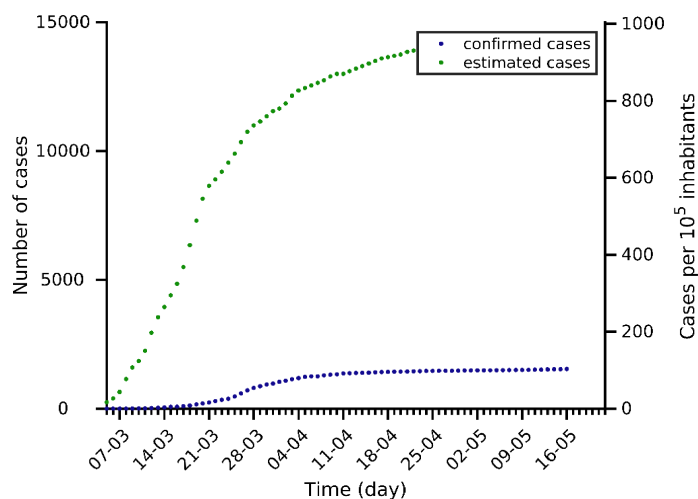
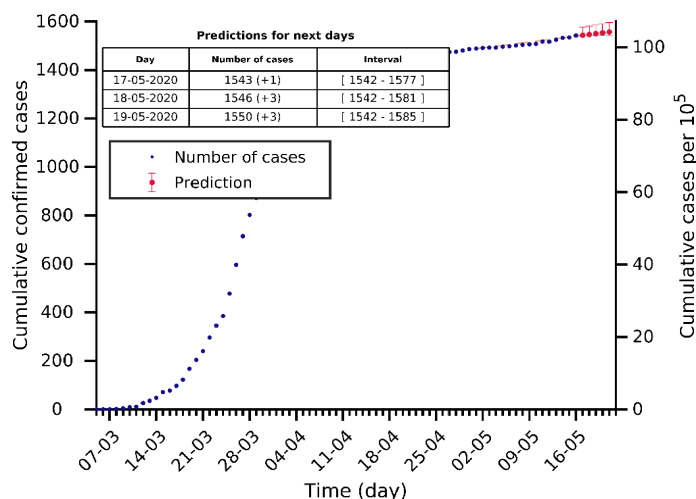
Cantabria 16-05-2020. Population: 0.6M. Current cumulated incidence: 390/10⁵



Baleares 16-05-2020. Population: 1.1M. Current cumulated incidence: 172/10⁵



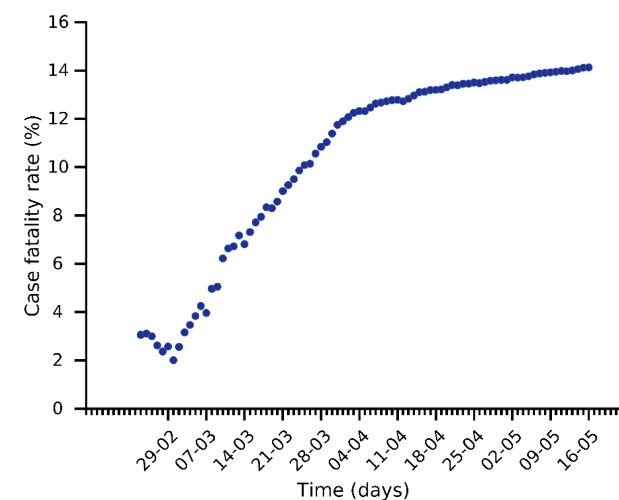
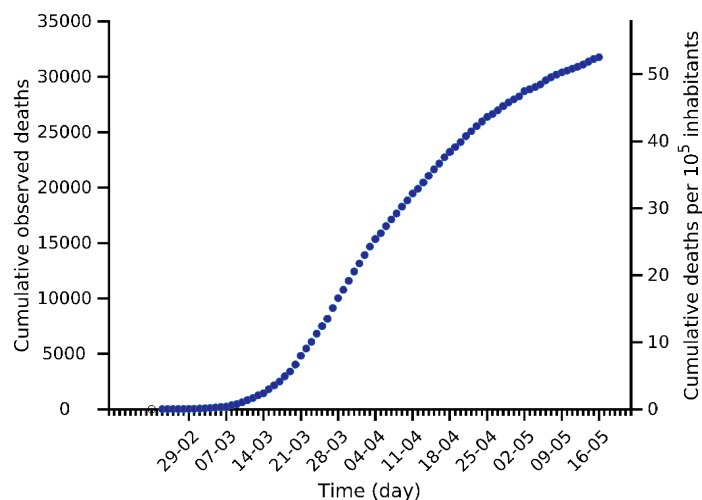
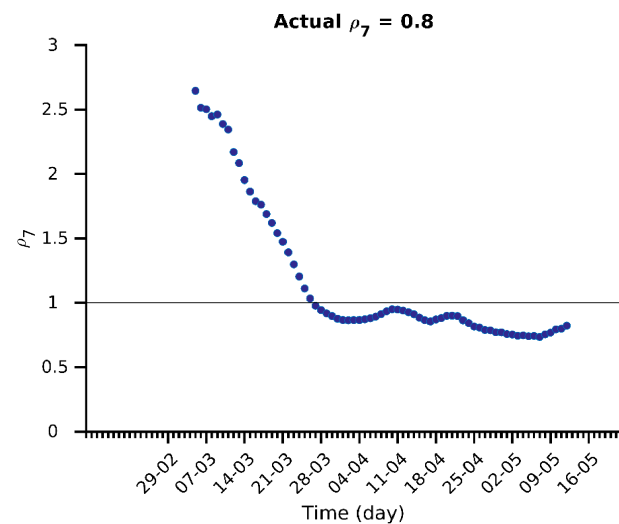
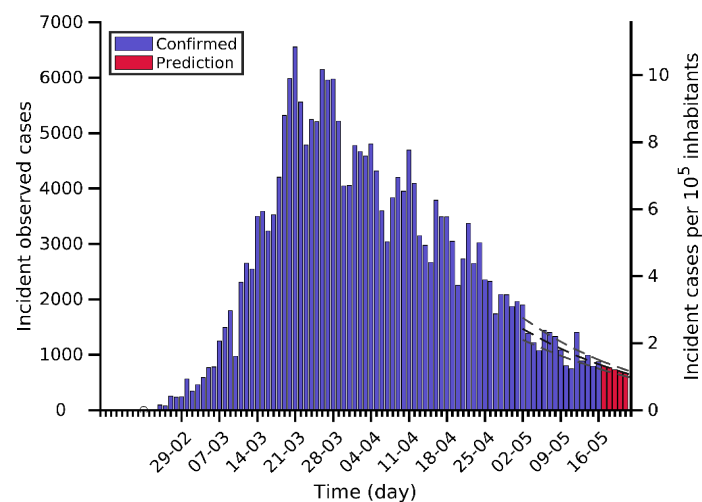
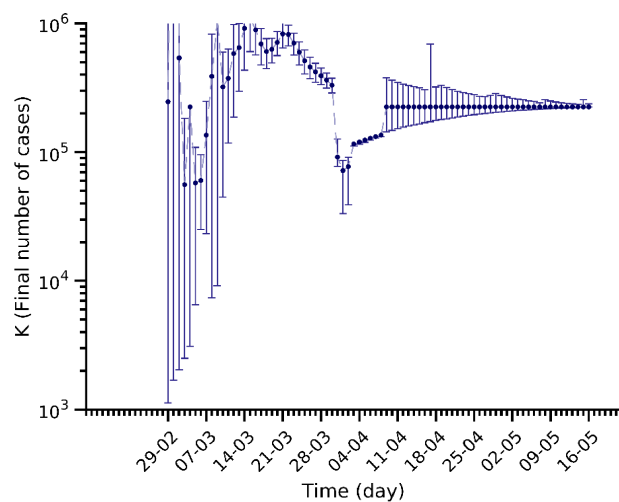
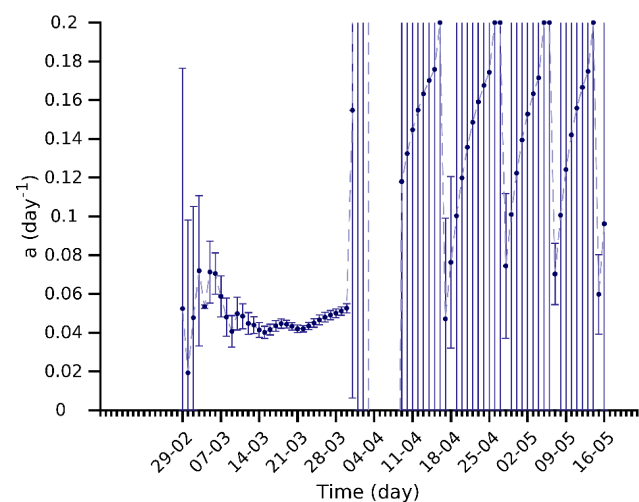
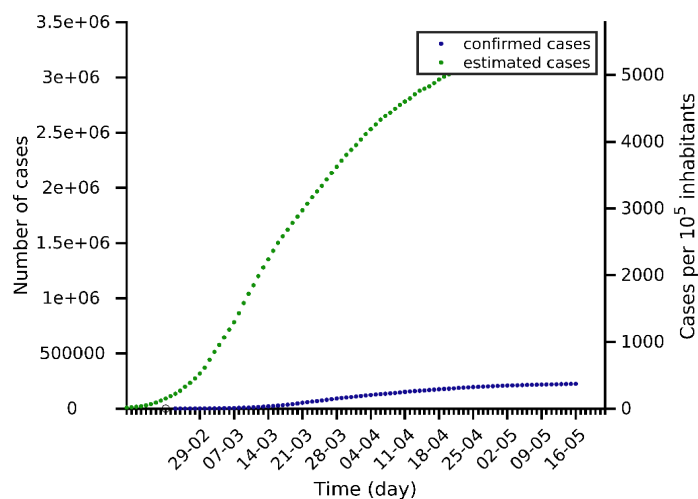
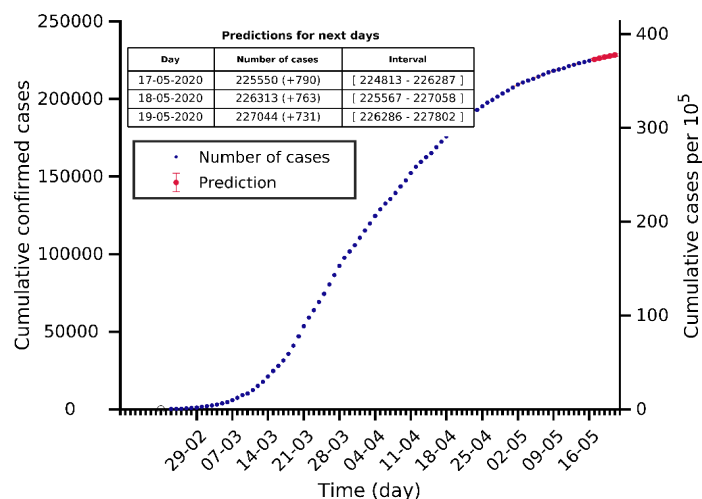
Murcia 16-05-2020. Population: 1.5M. Current cumulated incidence: 103/10⁵



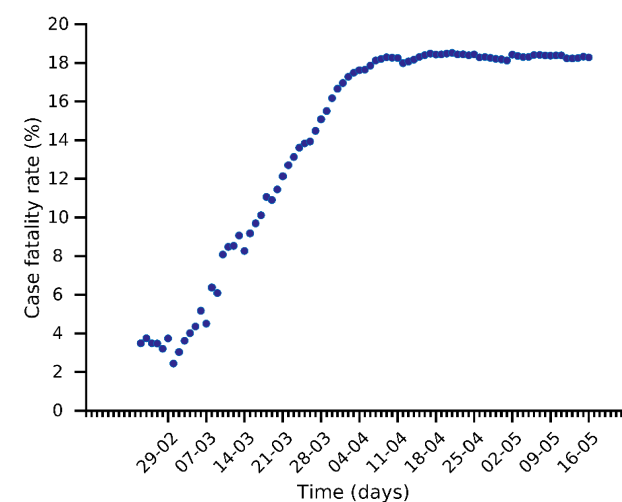
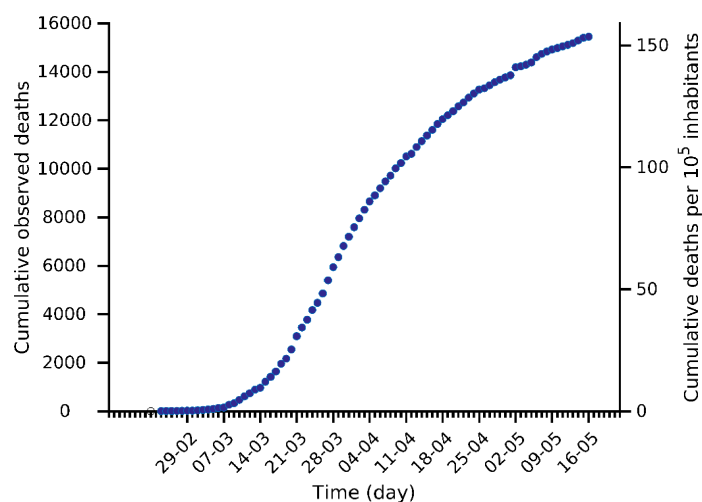
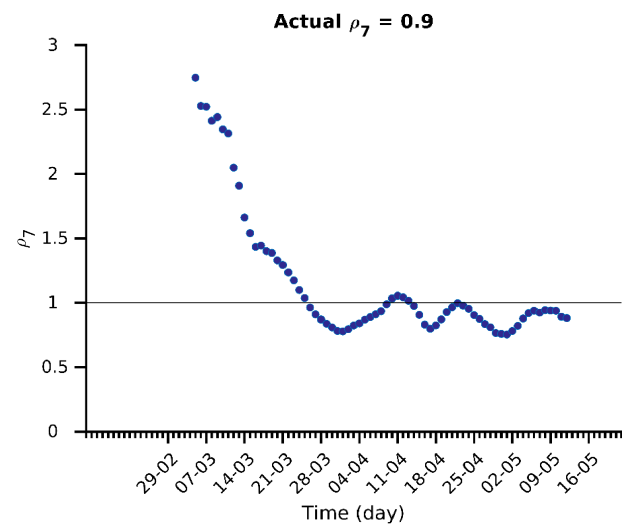
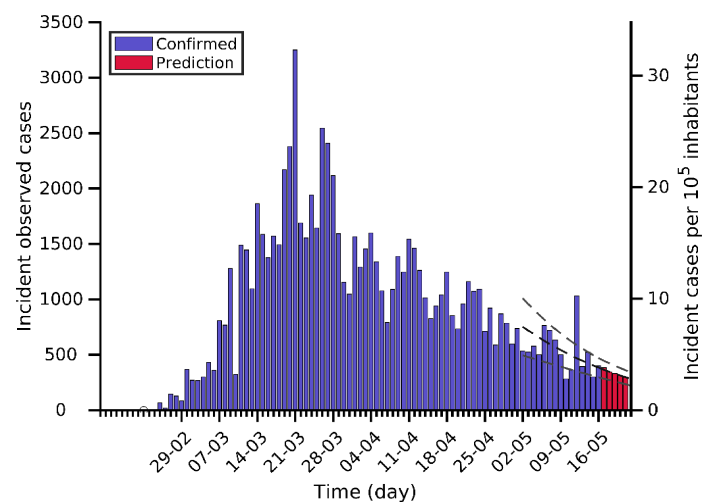
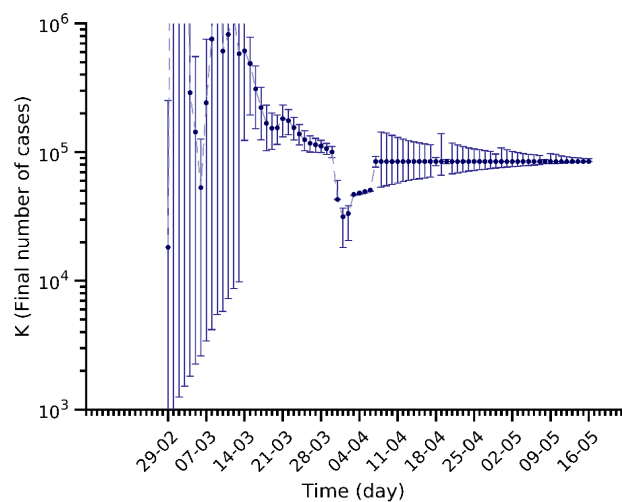
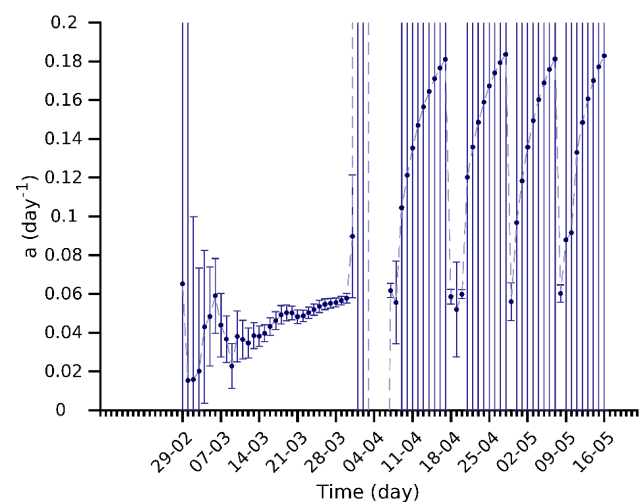
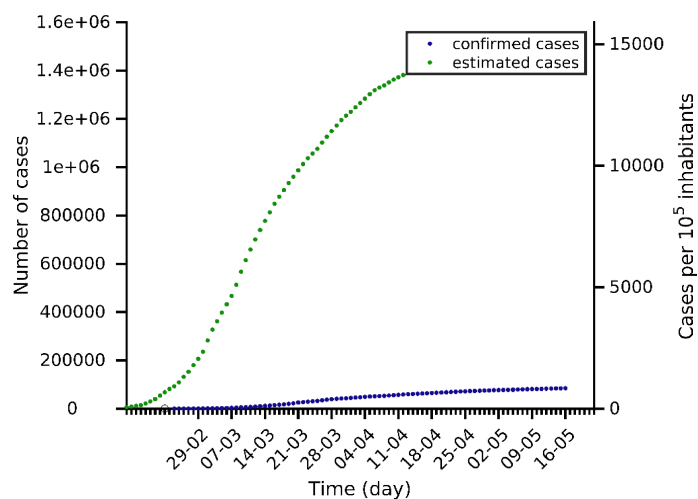
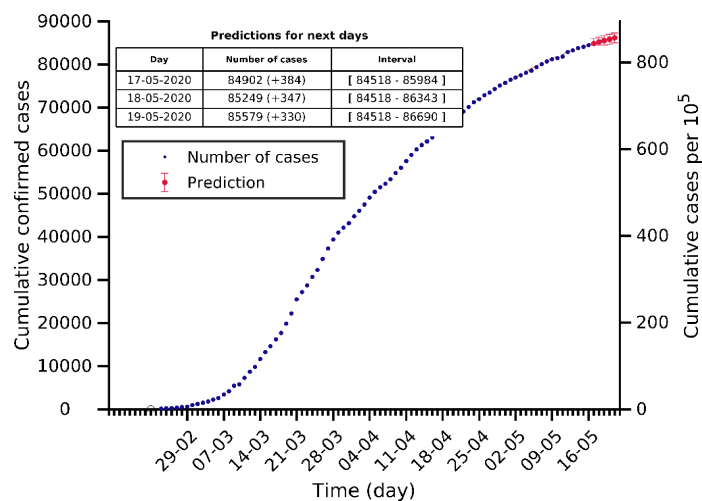
(4) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

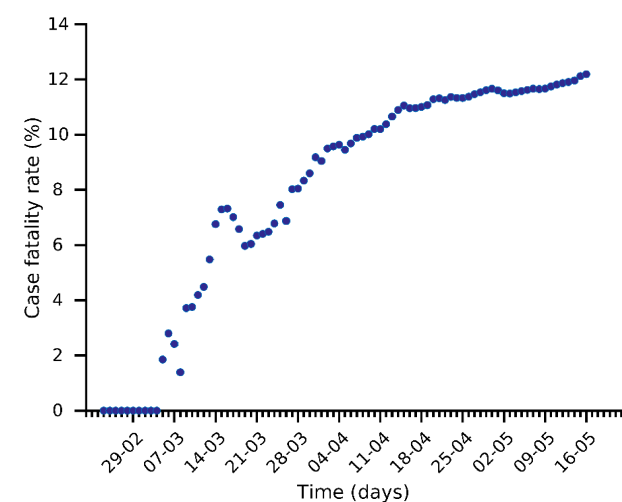
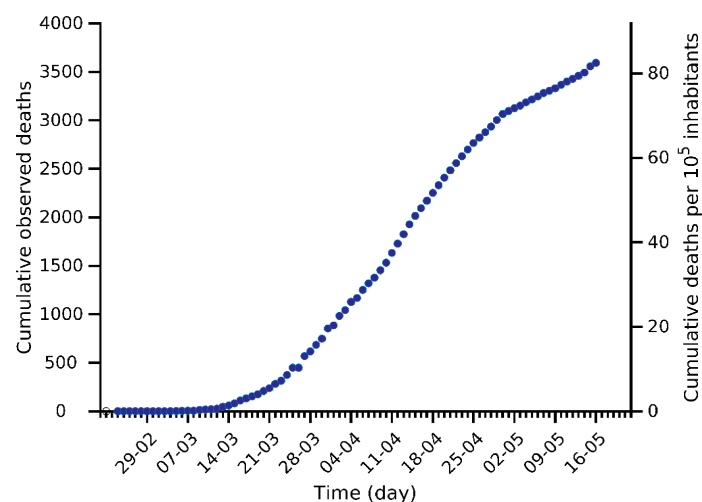
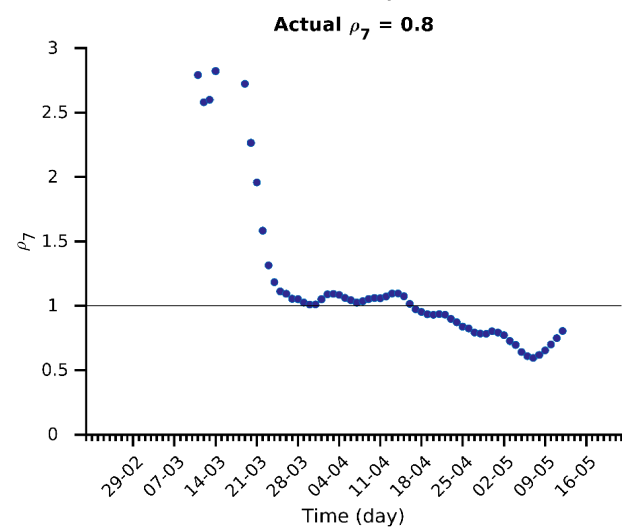
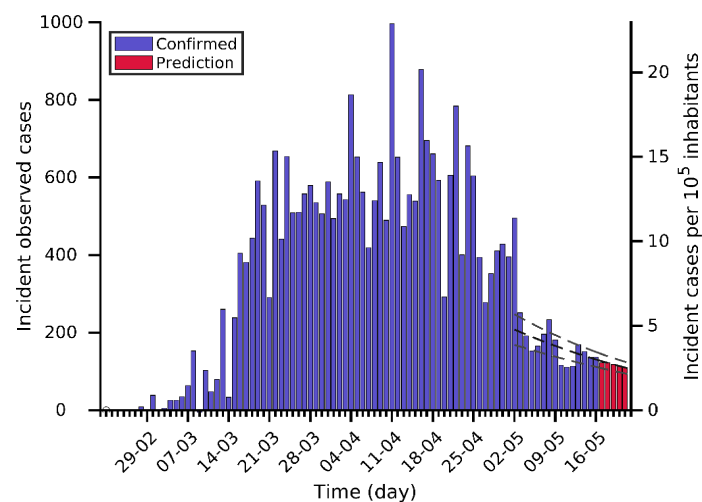
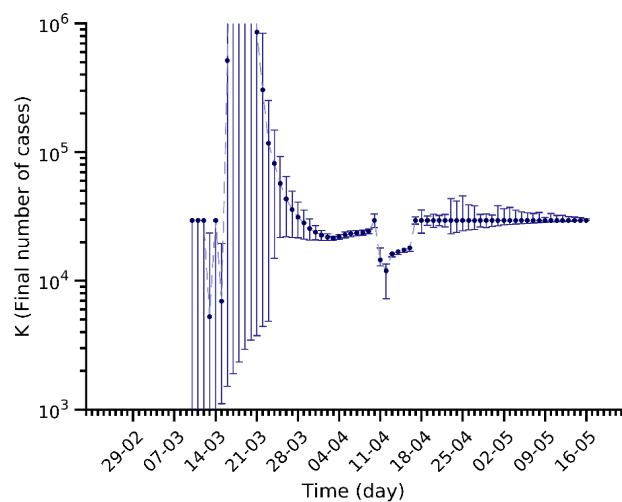
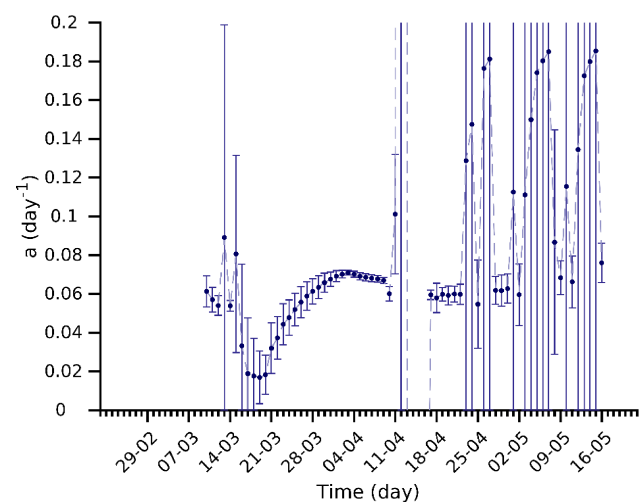
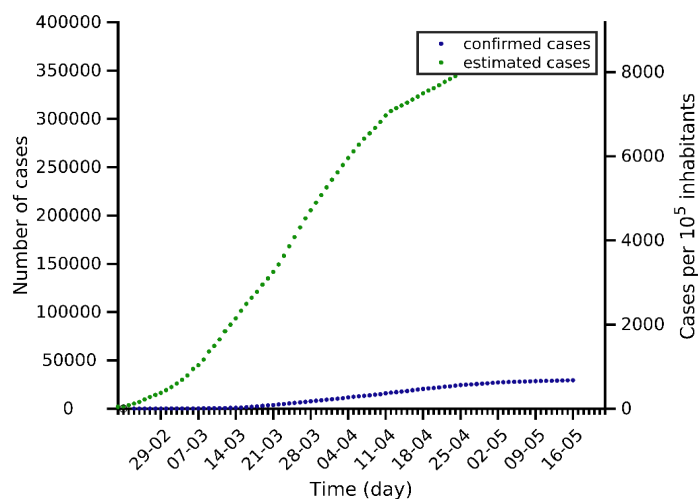
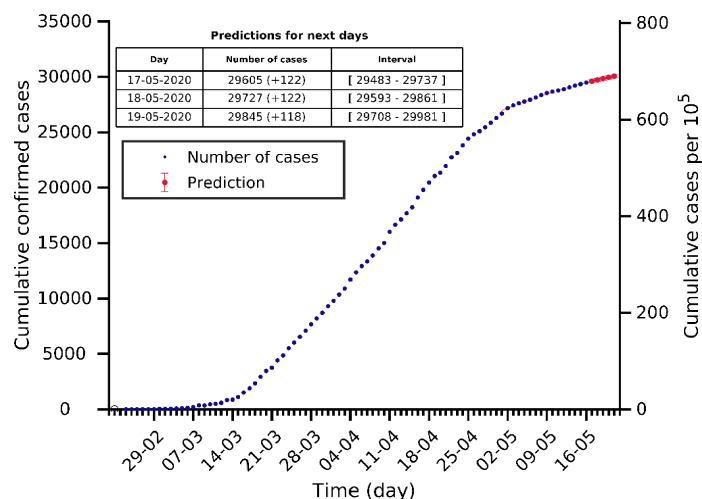
Italy 16-05-2020. Population: 60.5M. Current cumulated incidence: 372/10⁵



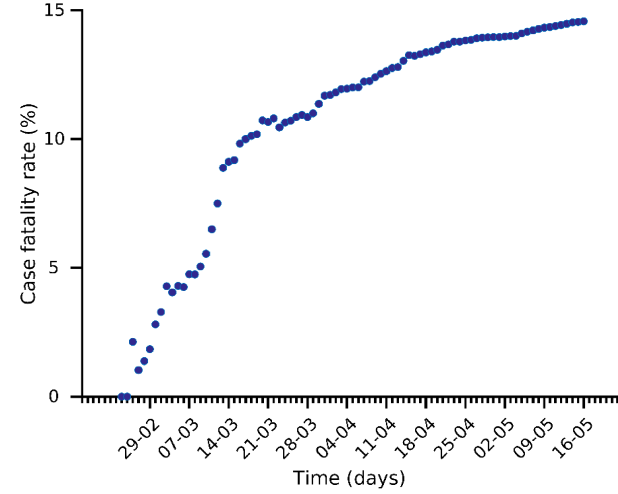
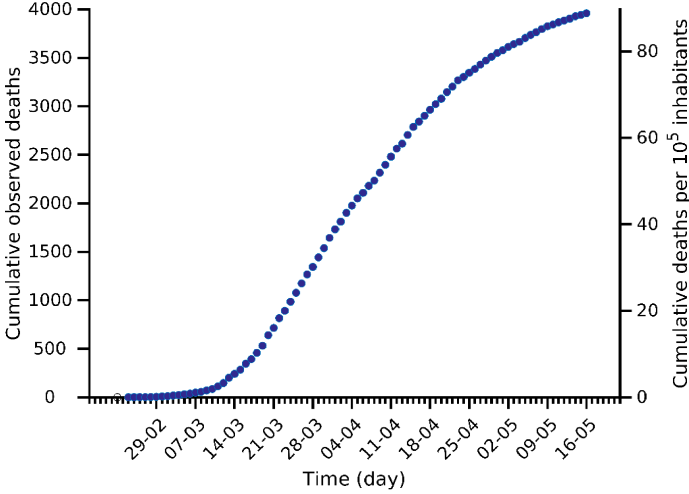
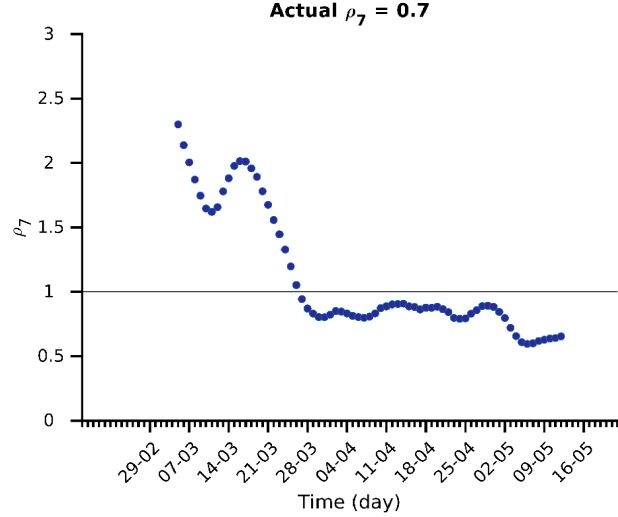
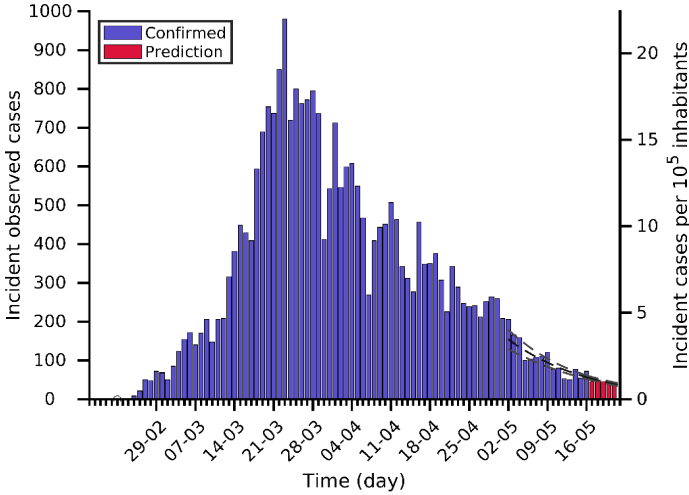
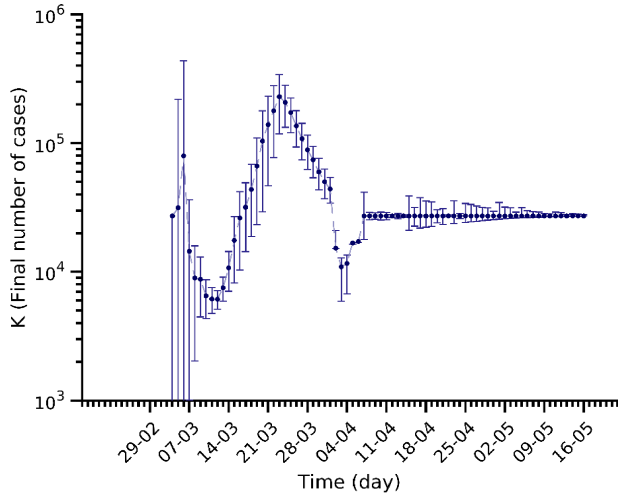
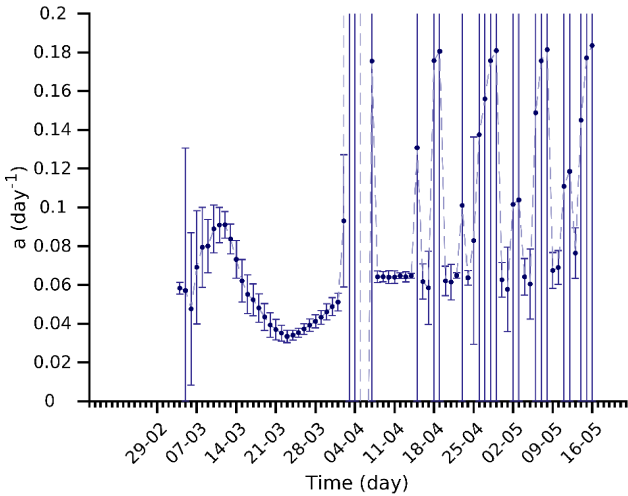
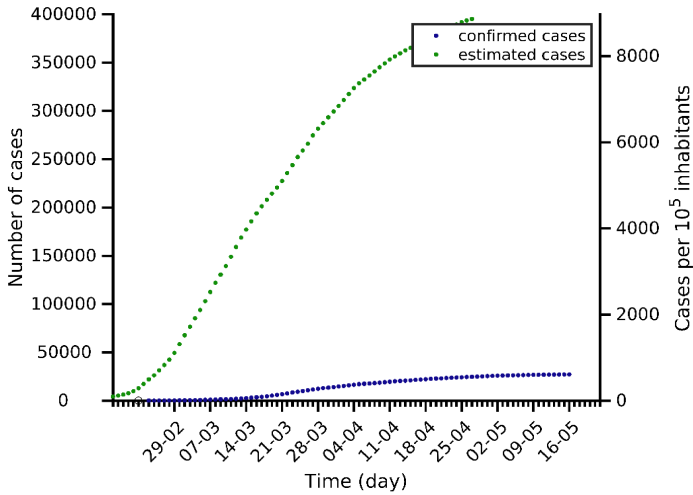
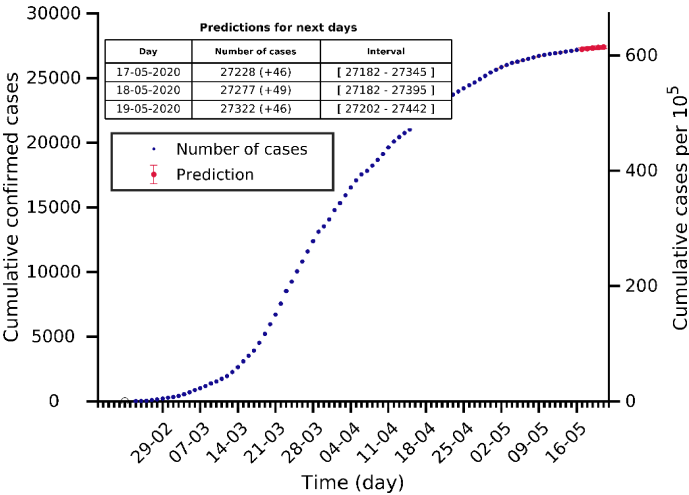
Lombardia 16-05-2020. Population: 10.1M. Current cumulated incidence: 840/10⁵



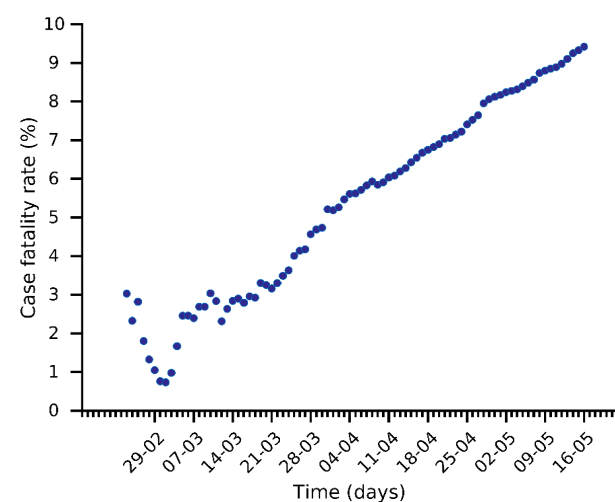
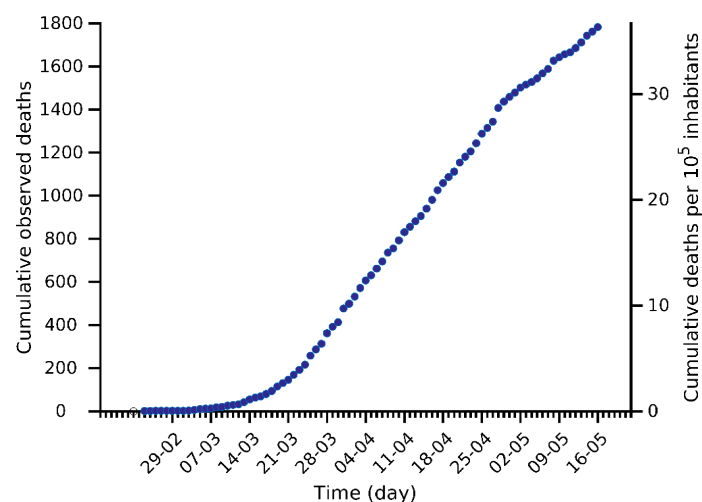
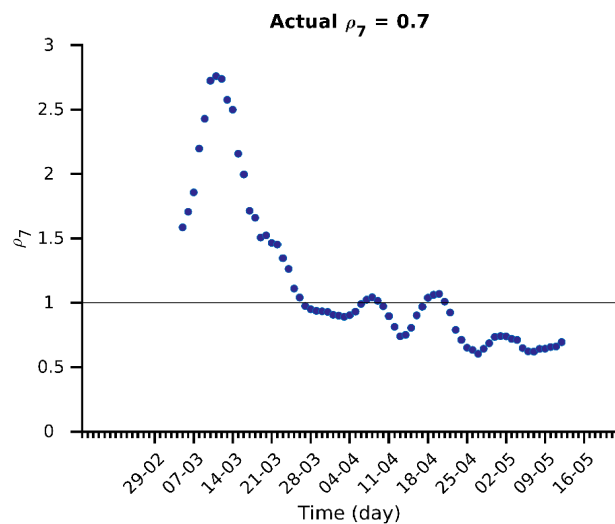
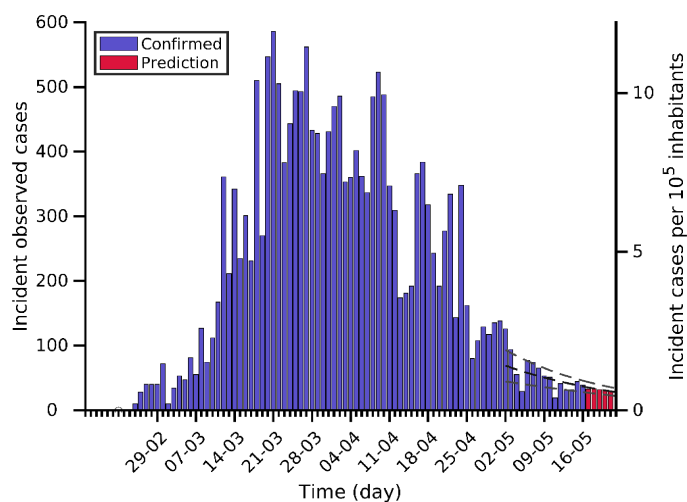
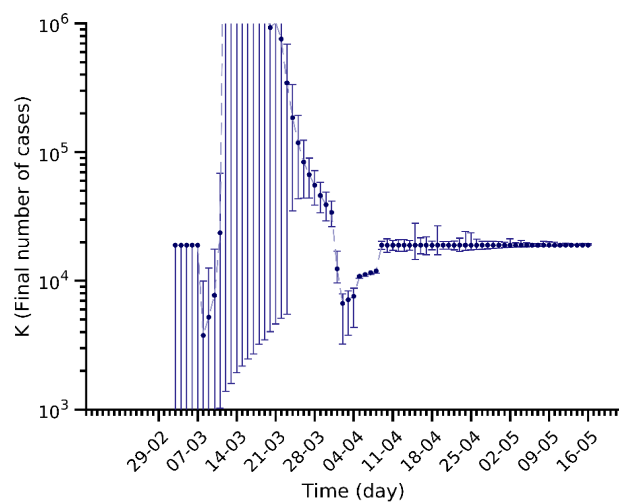
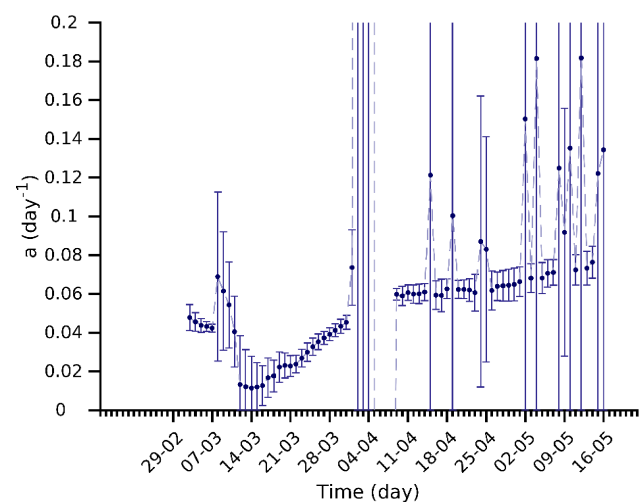
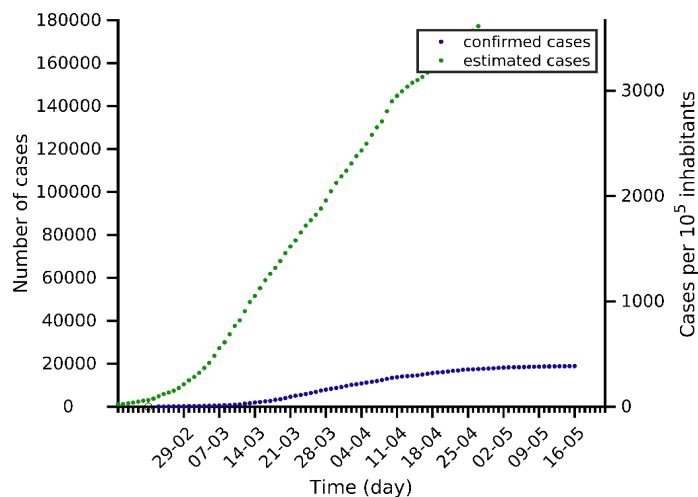
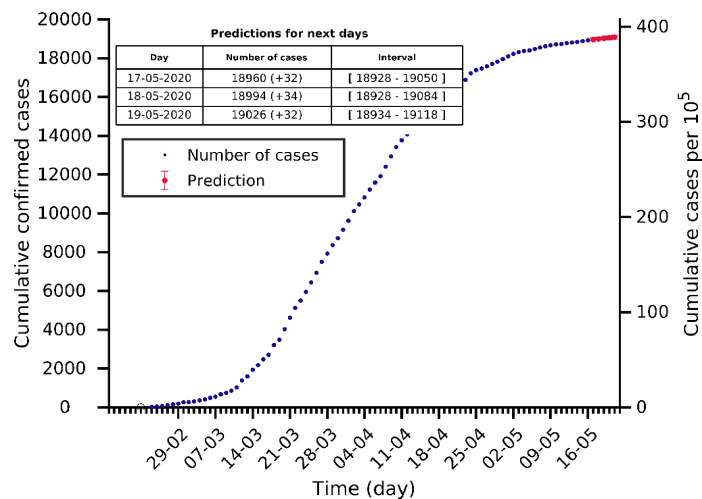
Piemonte 16-05-2020. Population: 4.4M. Current cumulated incidence: 677/10⁵



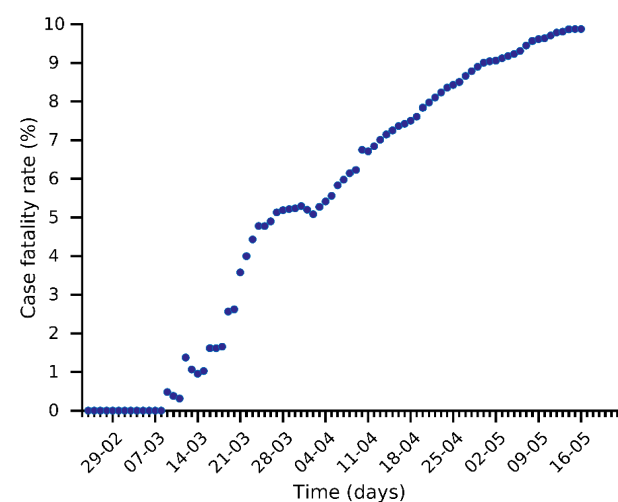
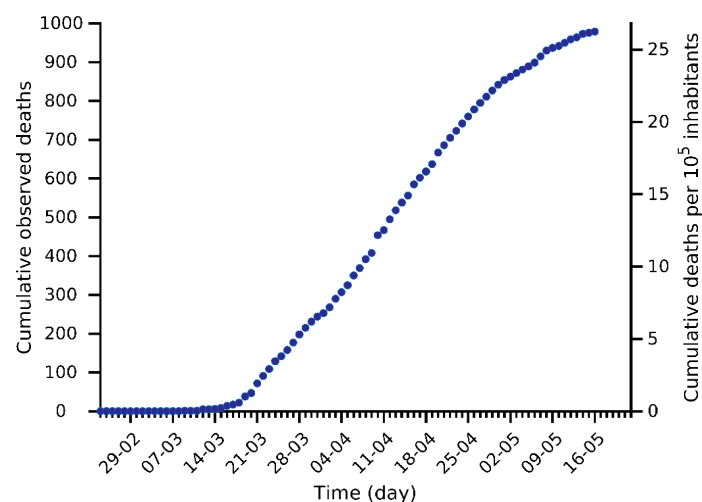
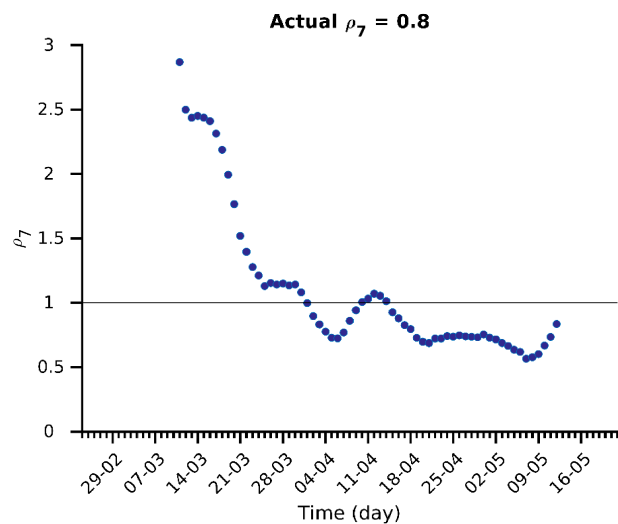
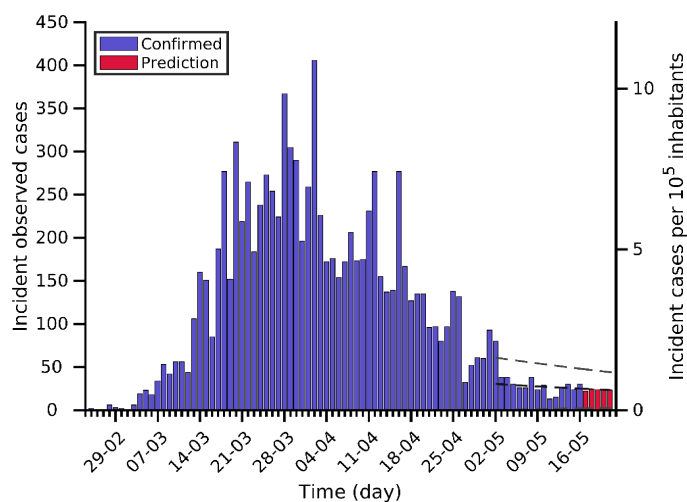
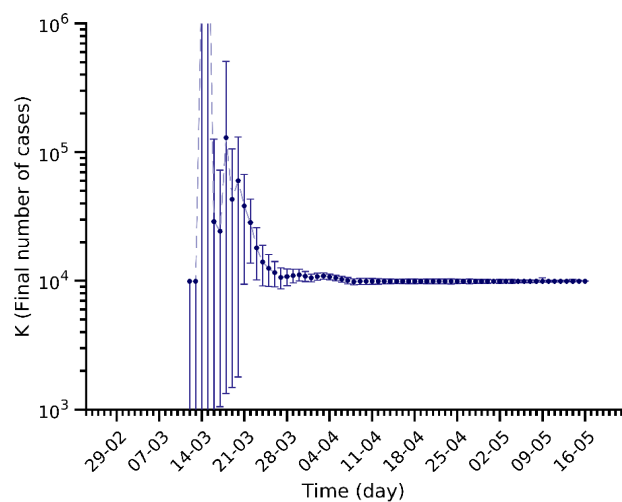
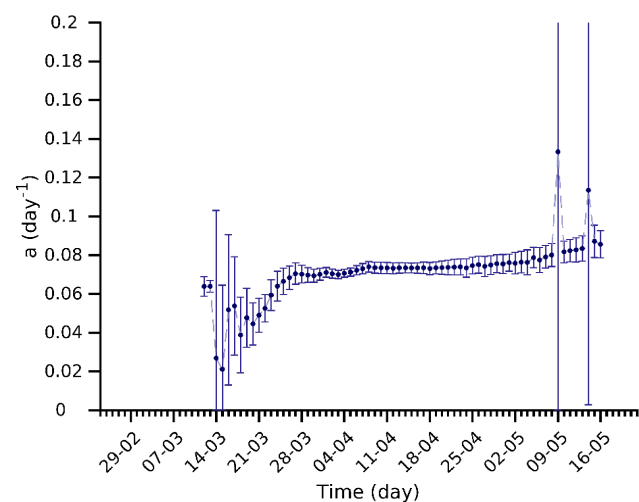
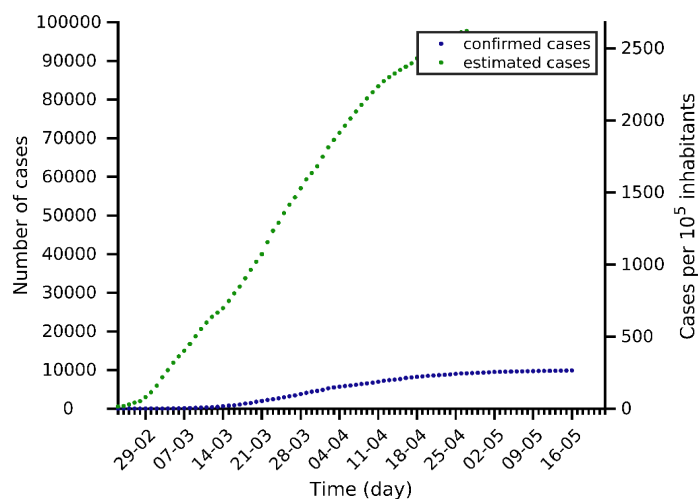
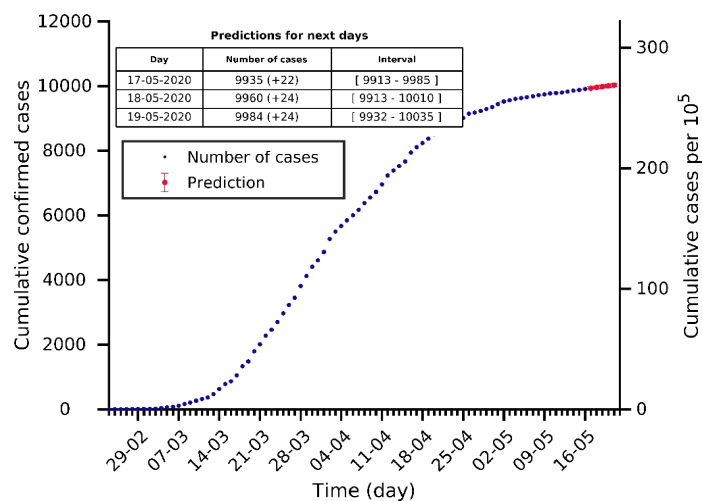
Emilia Romagna 16-05-2020. Population: 4.5M. Current cumulated incidence: 610/10⁵



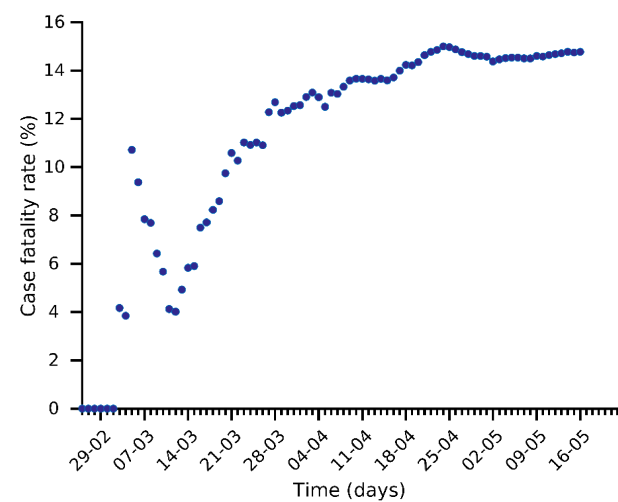
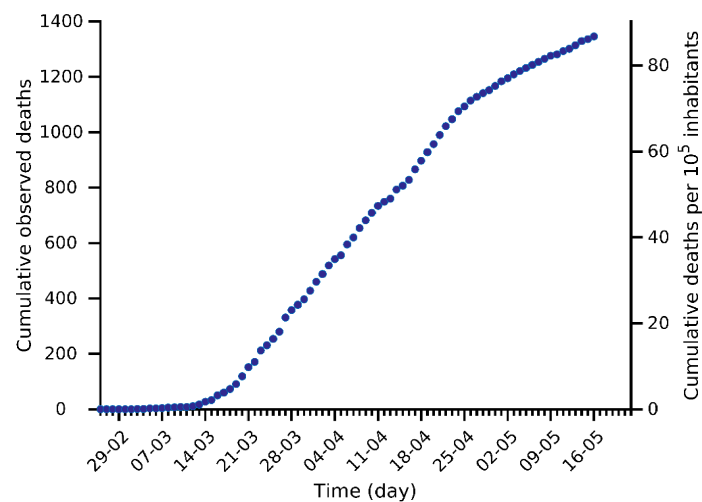
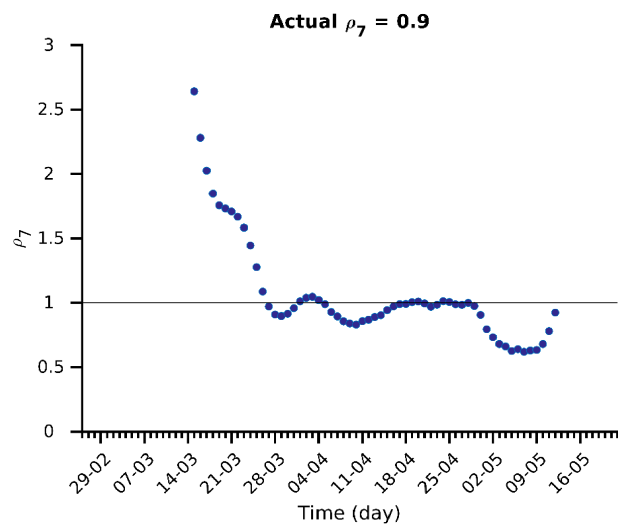
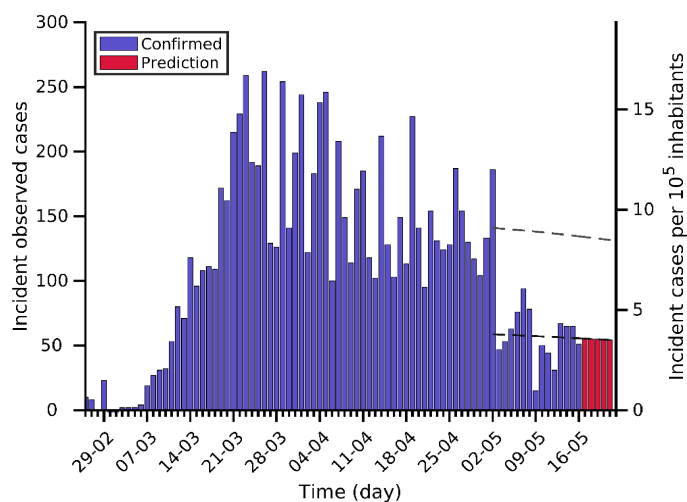
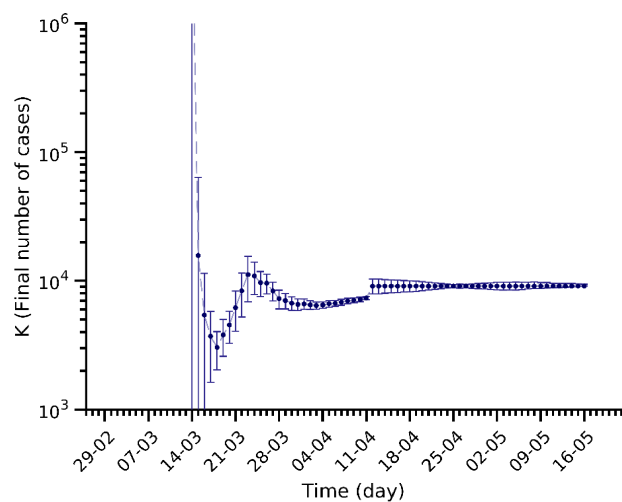
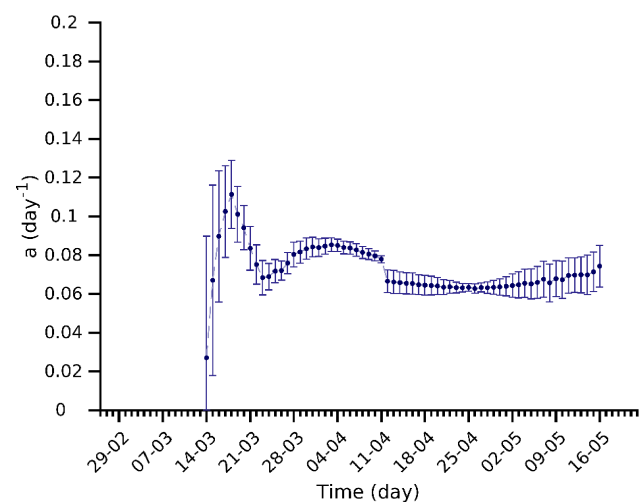
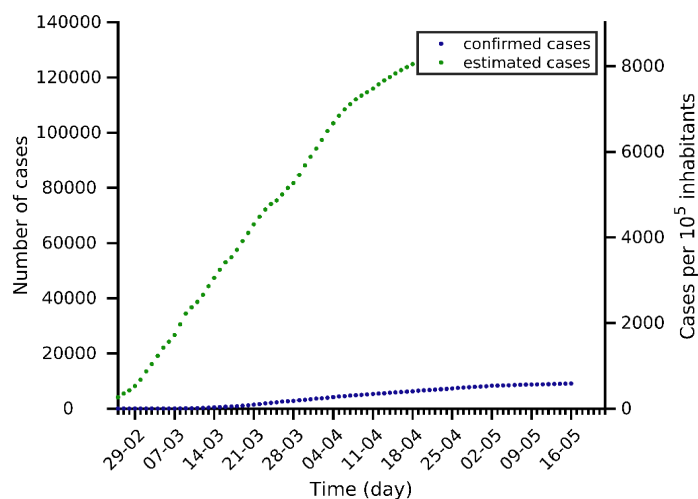
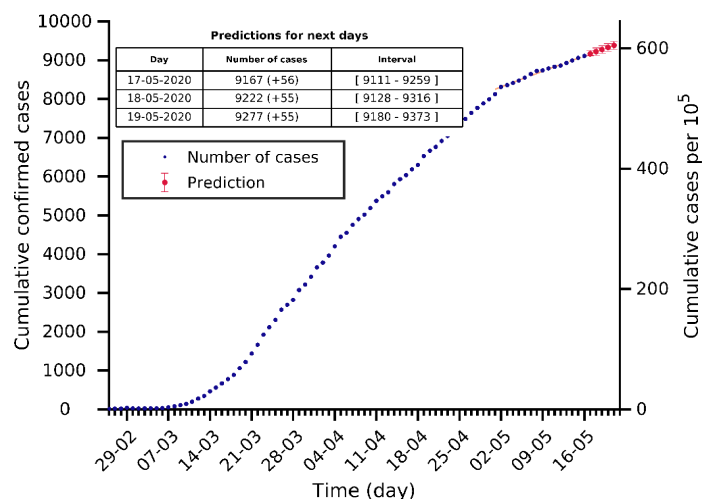
Veneto 16-05-2020. Population: 4.9M. Current cumulated incidence: 386/10⁵



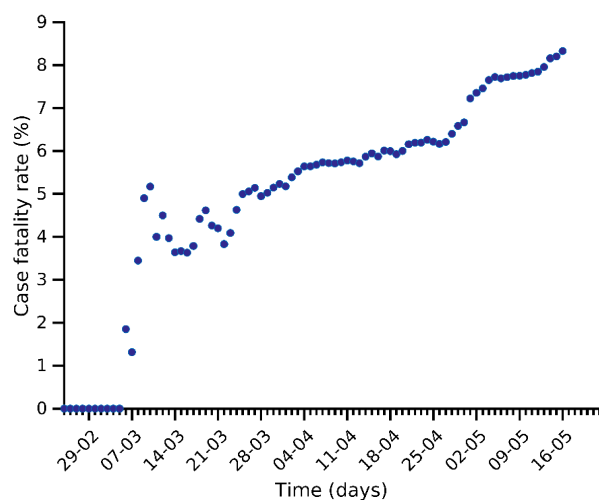
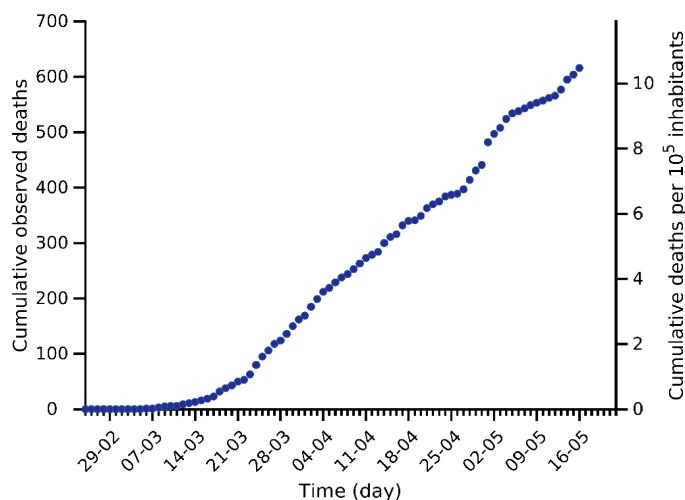
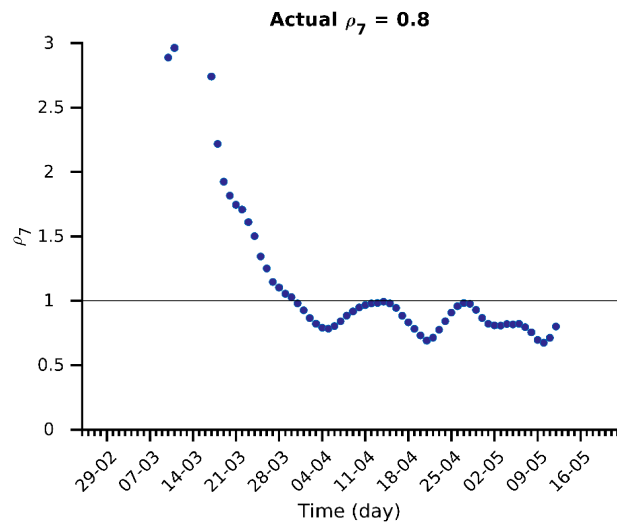
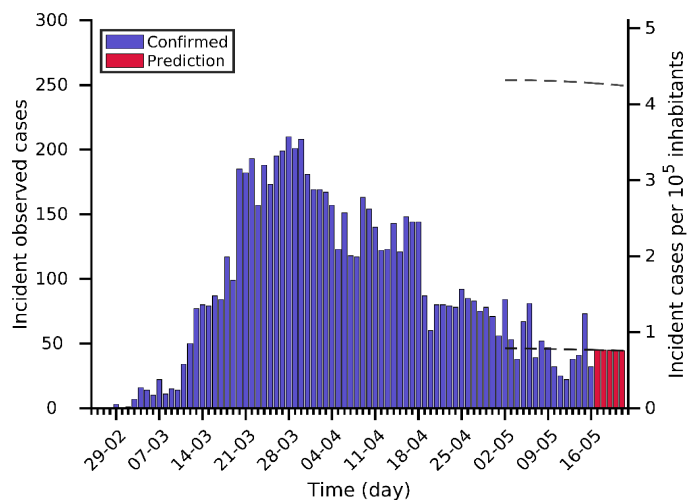
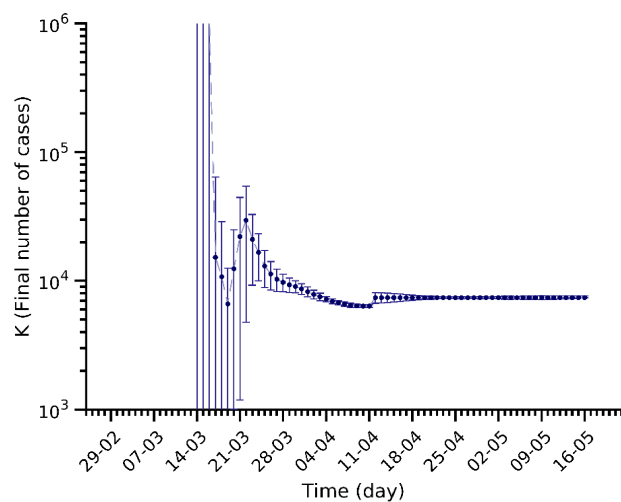
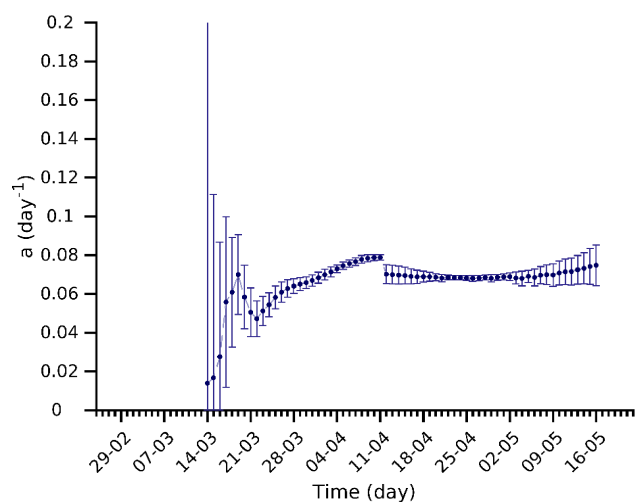
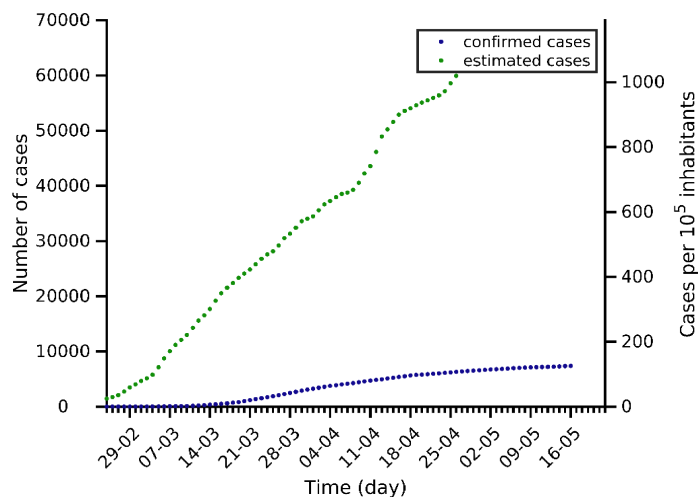
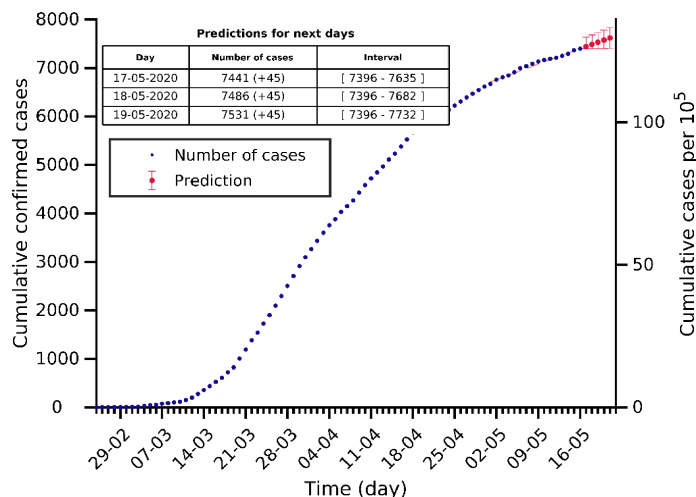
Toscana 16-05-2020. Population: 3.7M. Current cumulated incidence: 266/10⁵



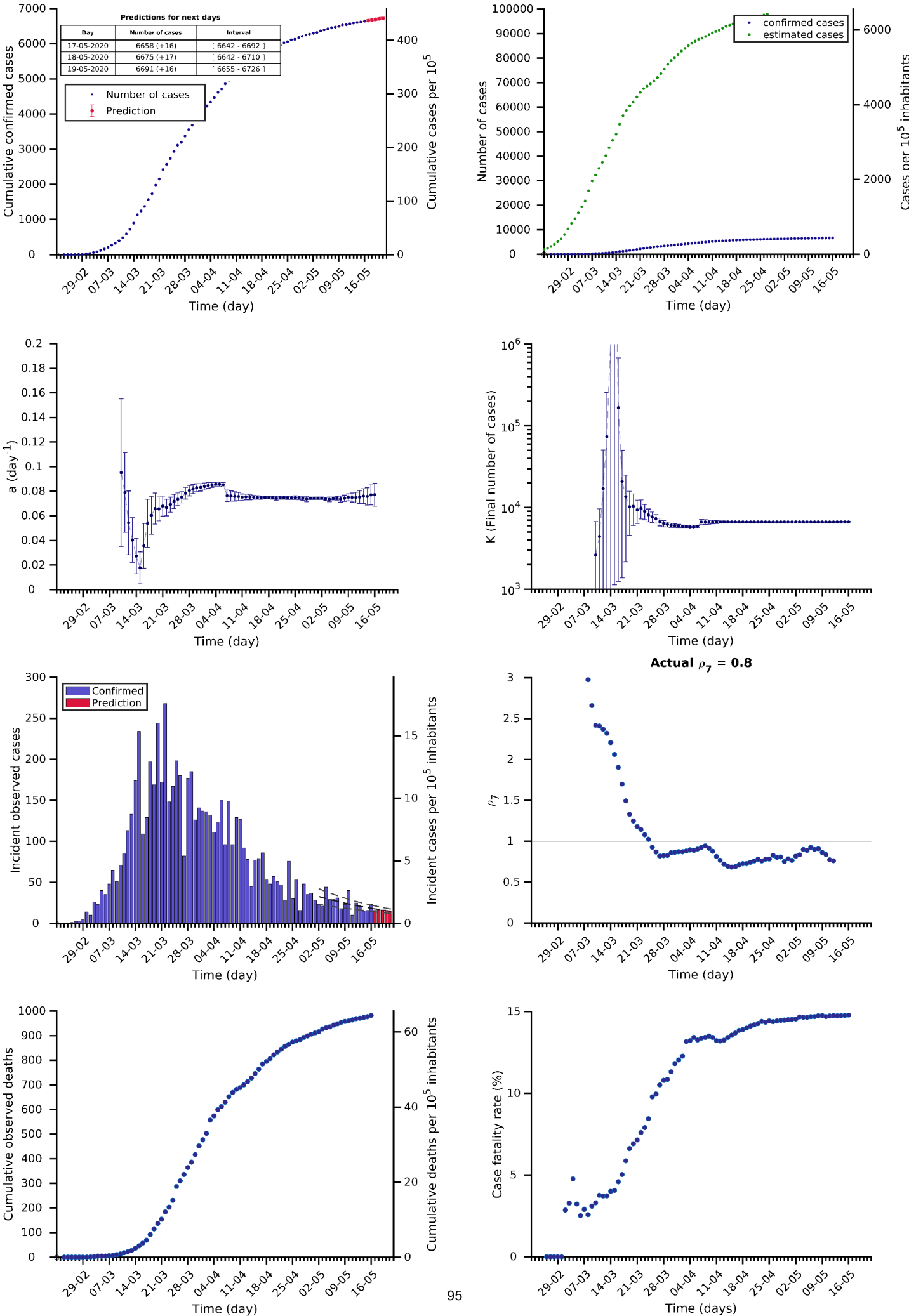
Liguria 16-05-2020. Population: 1.6M. Current cumulated incidence: 587/10⁵



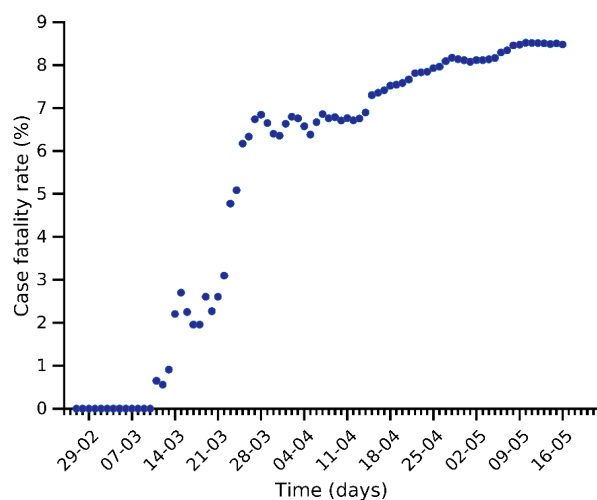
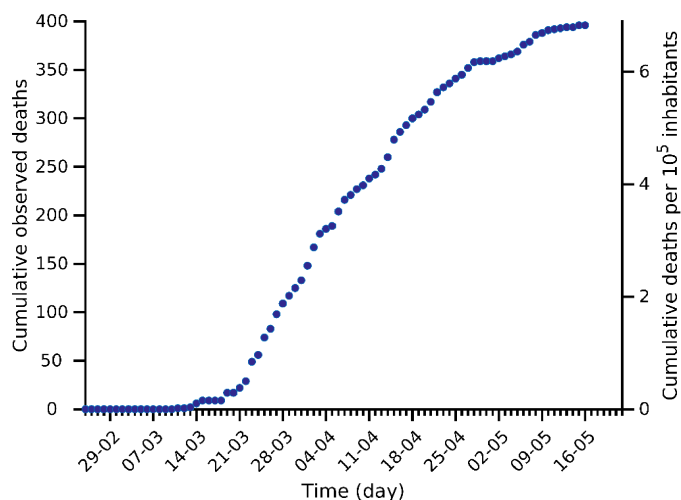
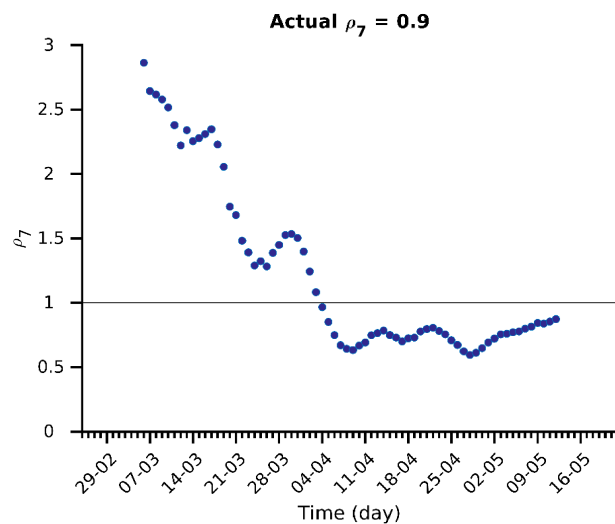
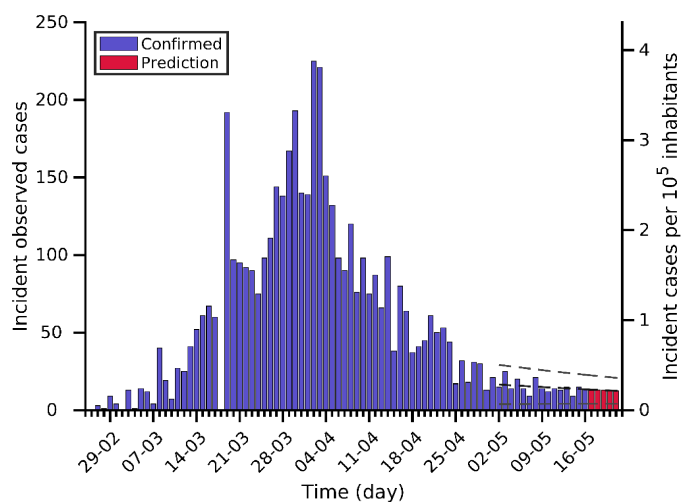
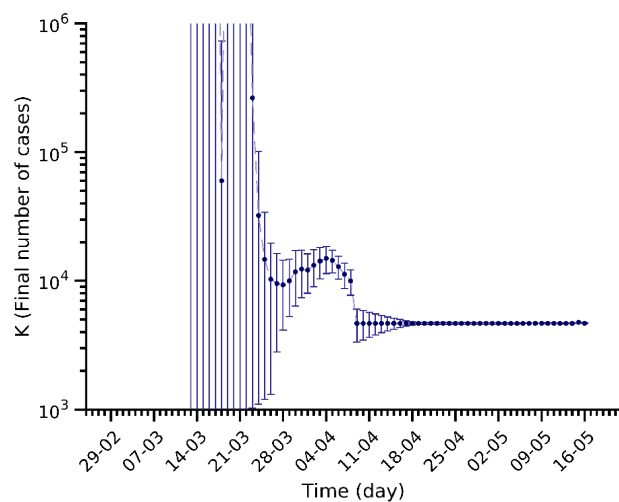
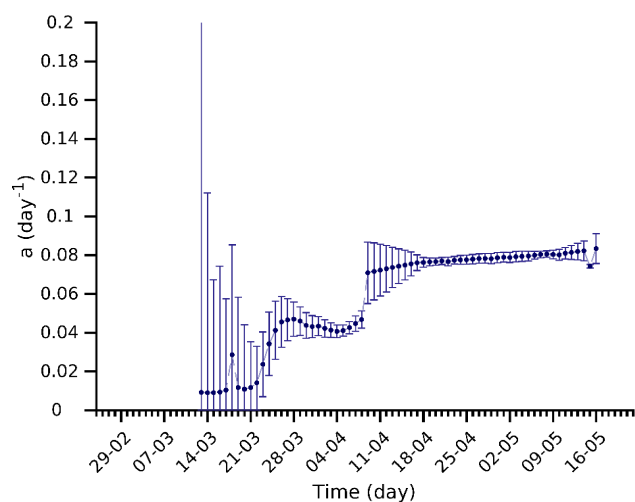
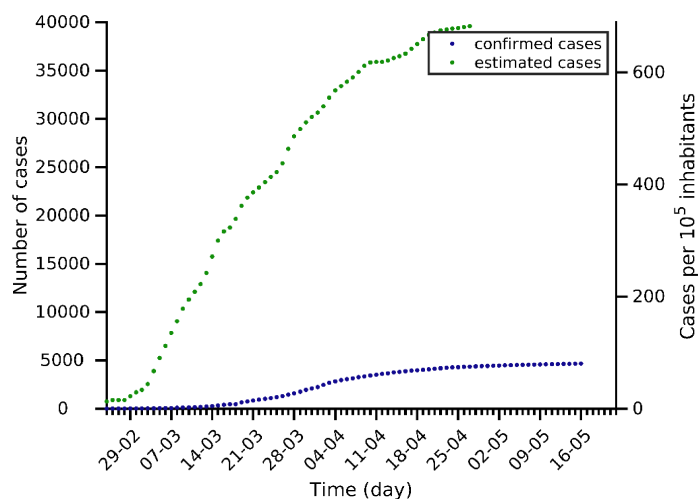
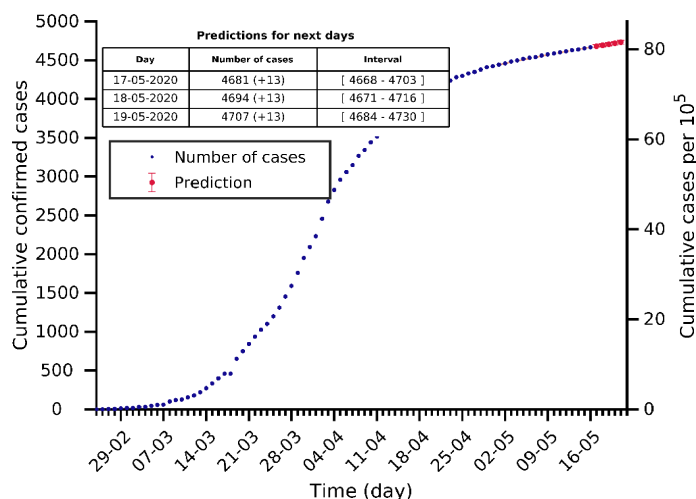
Lazio 16-05-2020. Population: 5.9M. Current cumulated incidence: 126/10⁵



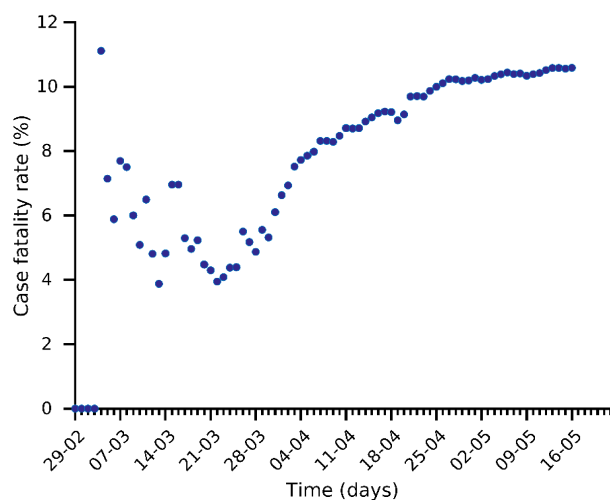
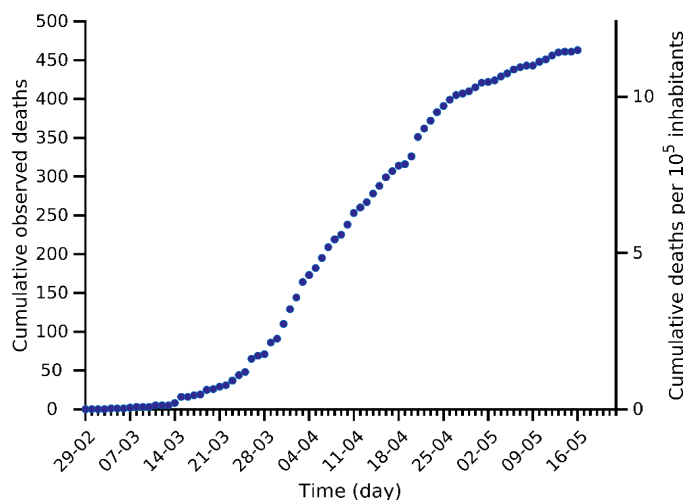
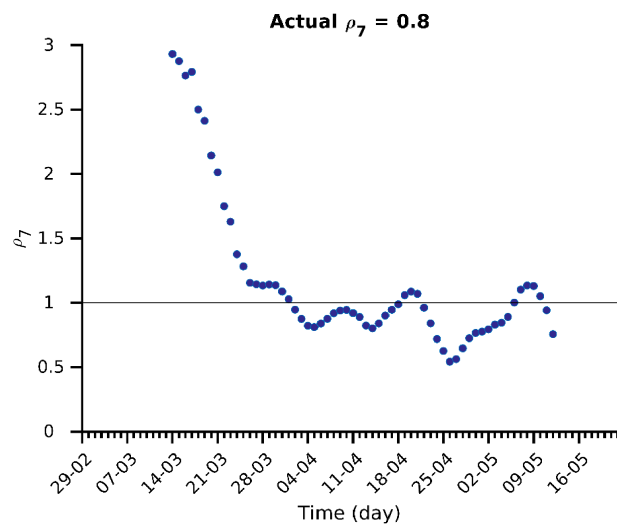
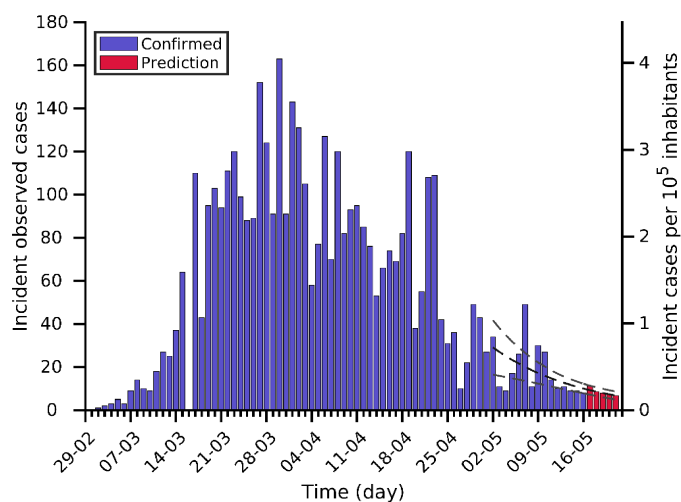
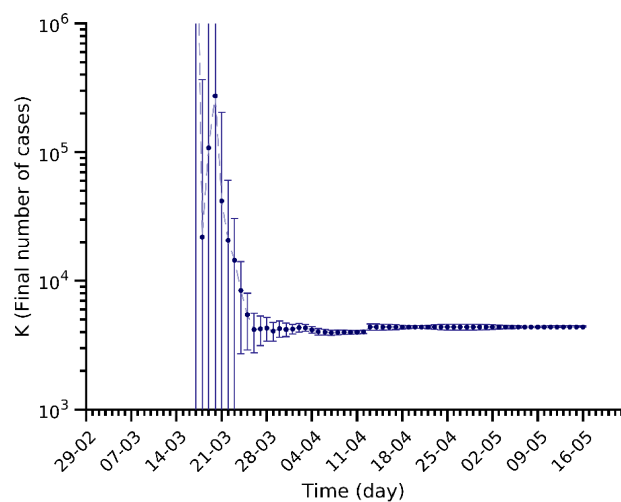
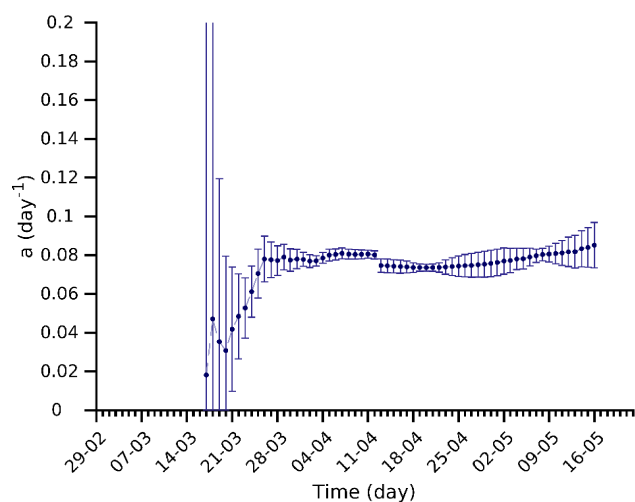
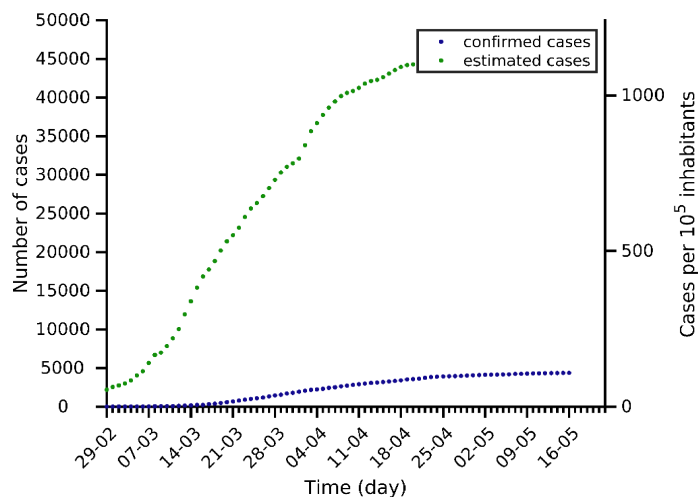
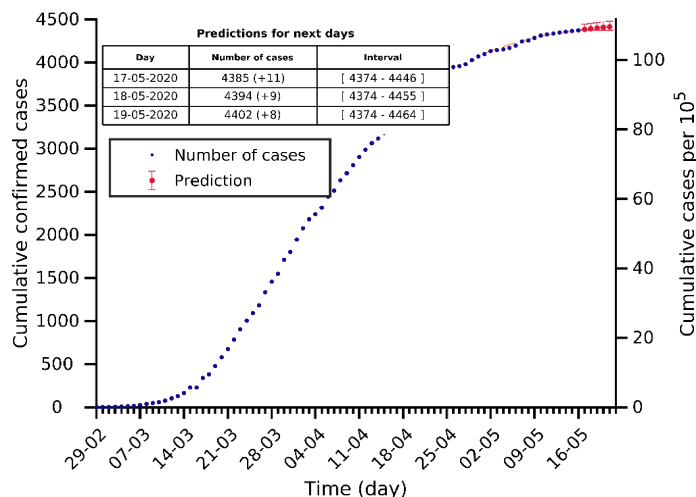
Marche
 16-05-2020.
 Population: 1.5M.
 Current cumulated incidence: 436/10⁵



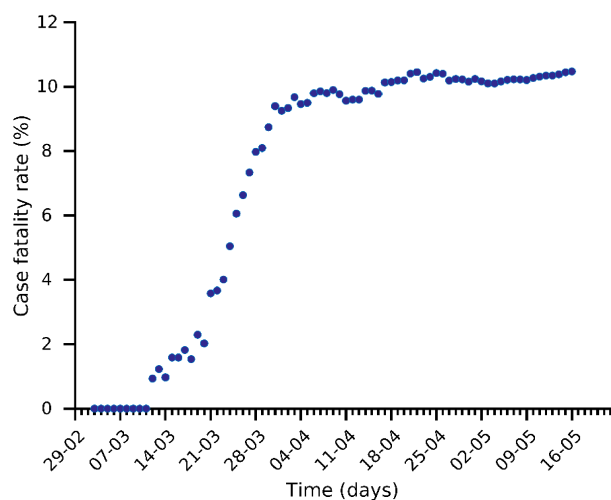
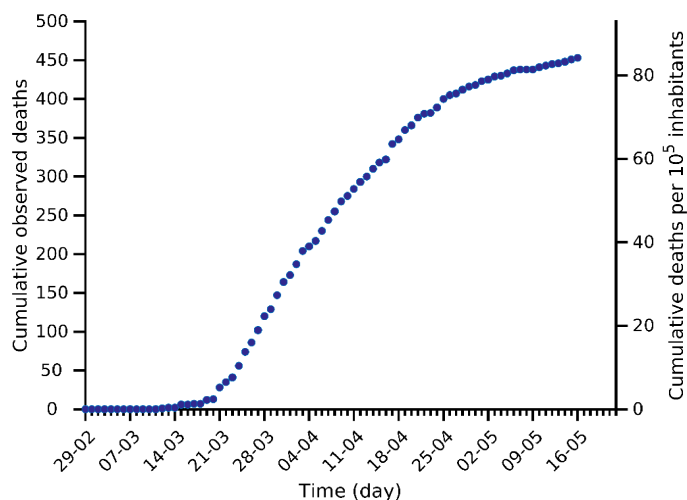
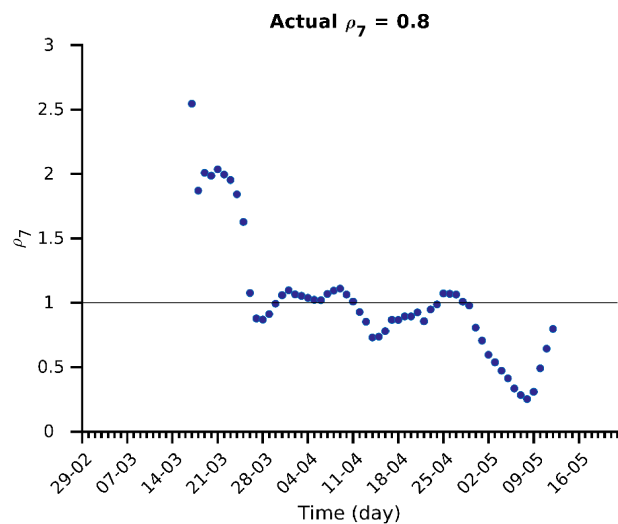
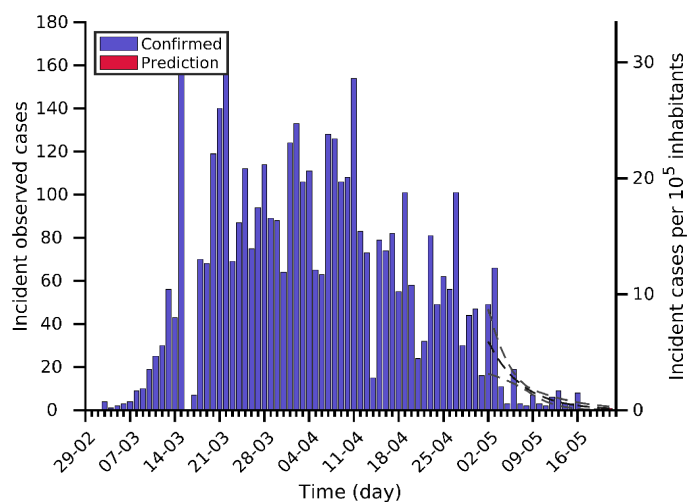
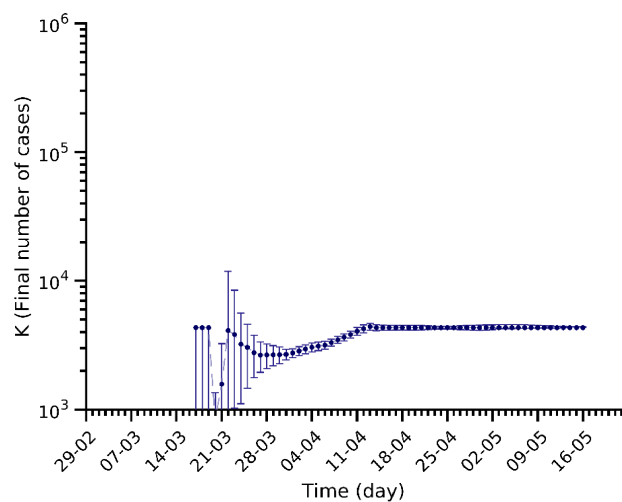
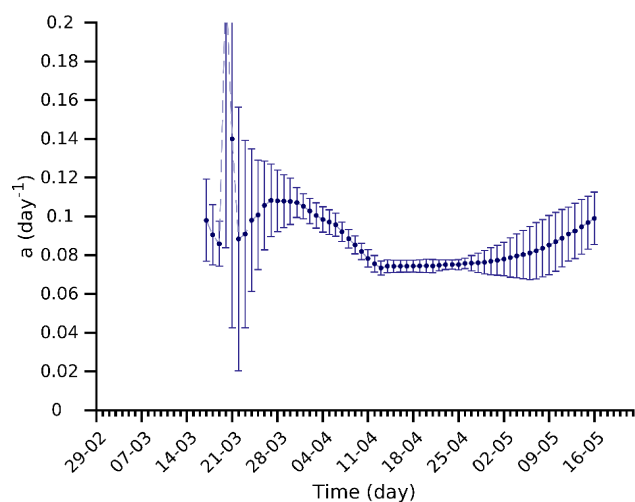
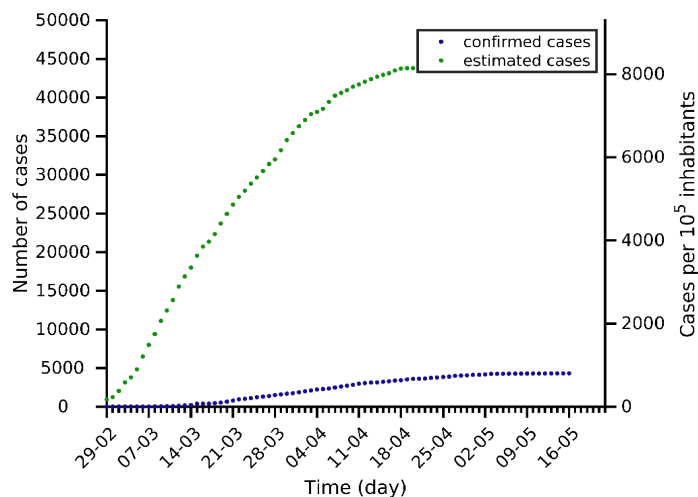
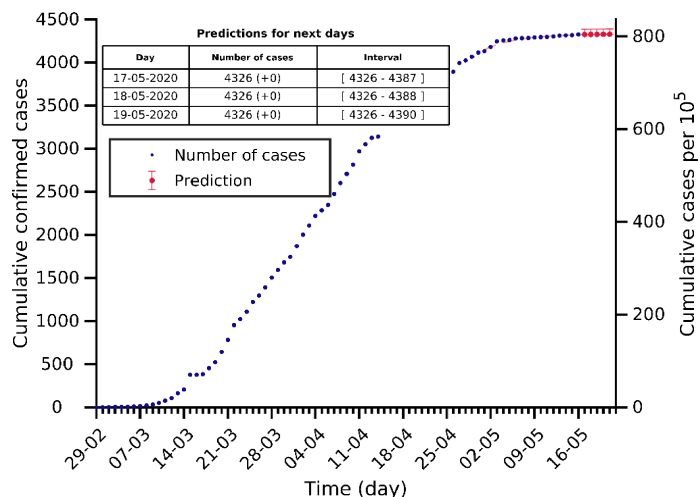
Campania 16-05-2020. Population: 5.8M. Current cumulated incidence: 80/10⁵



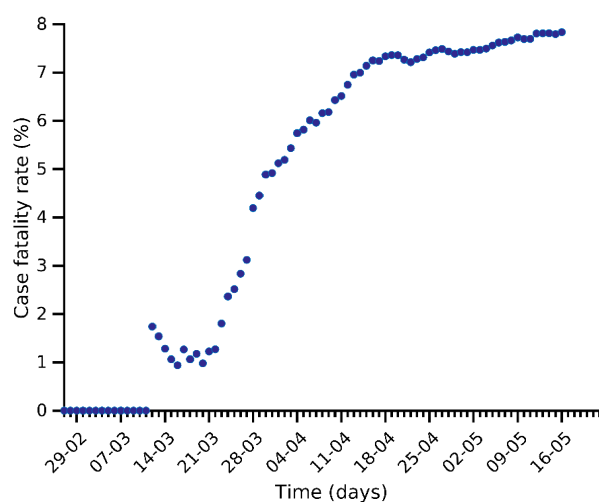
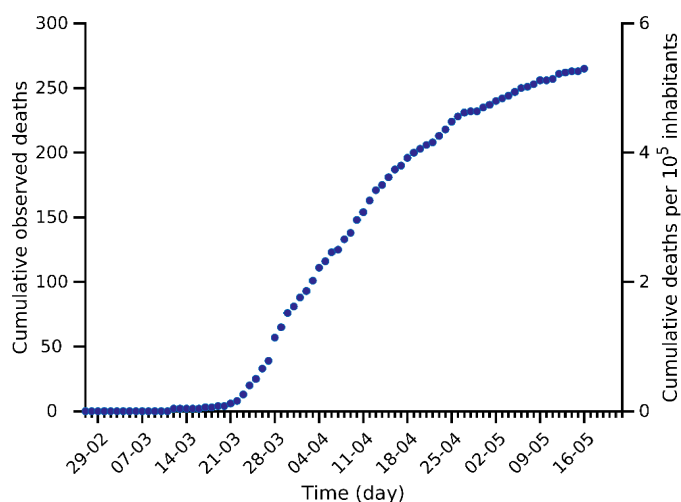
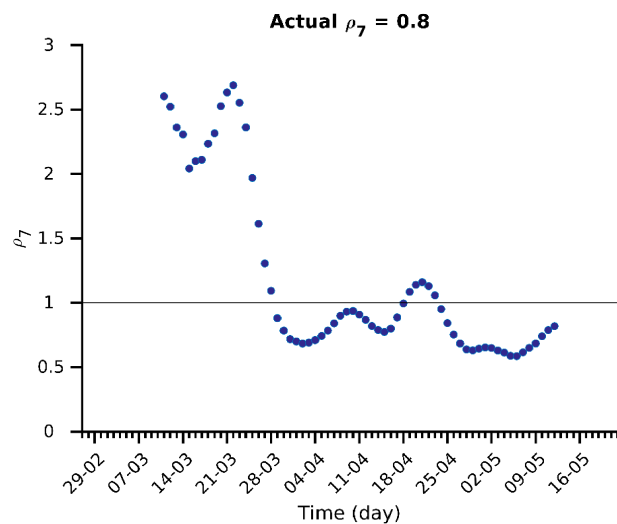
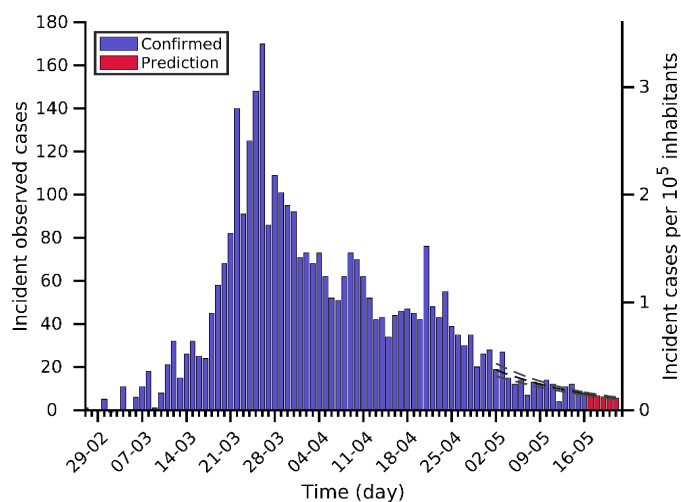
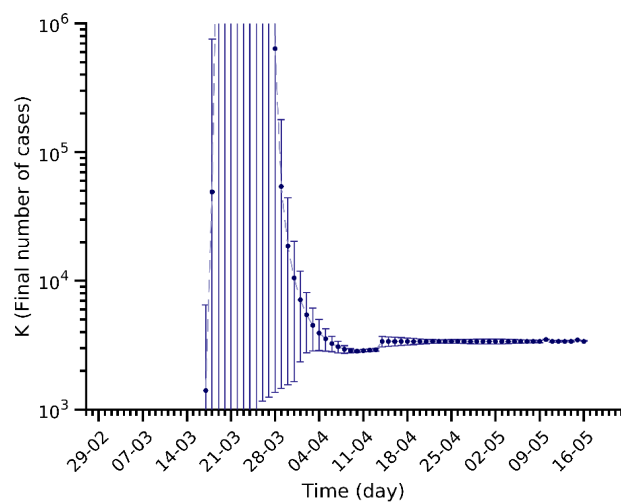
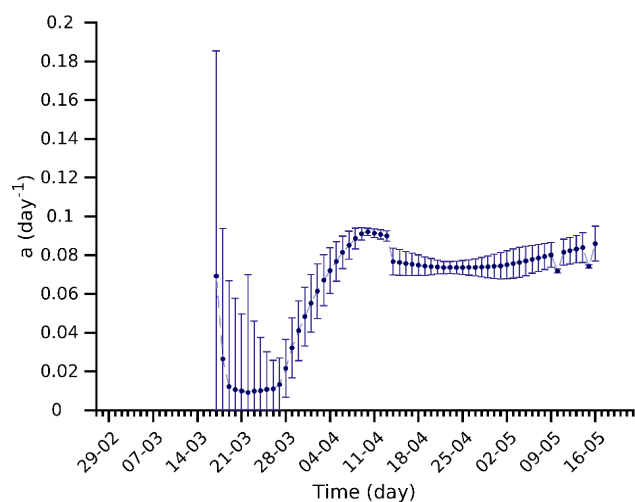
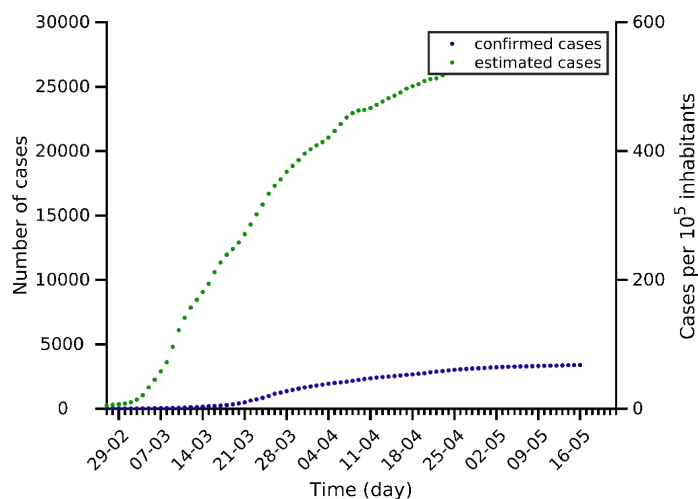
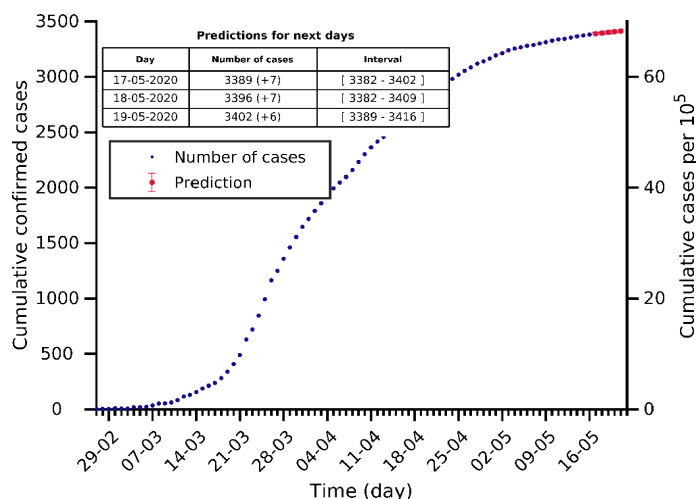
Puglia 16-05-2020. Population: 4.0M. Current cumulated incidence: 109/10⁵



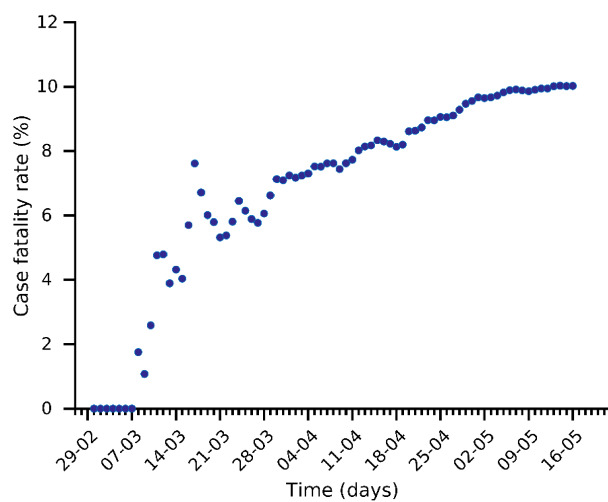
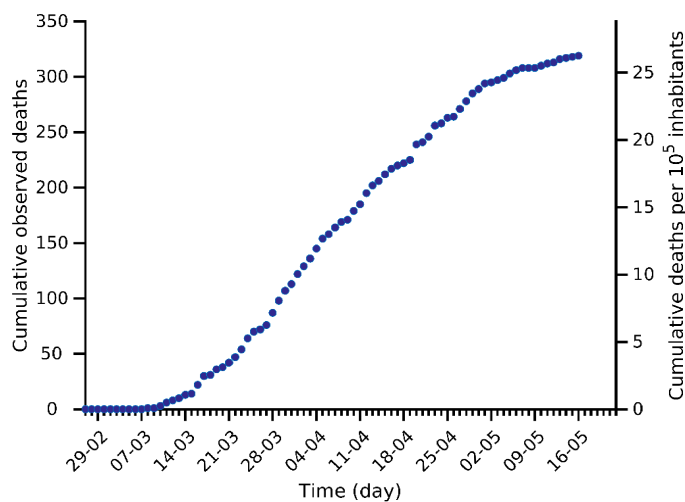
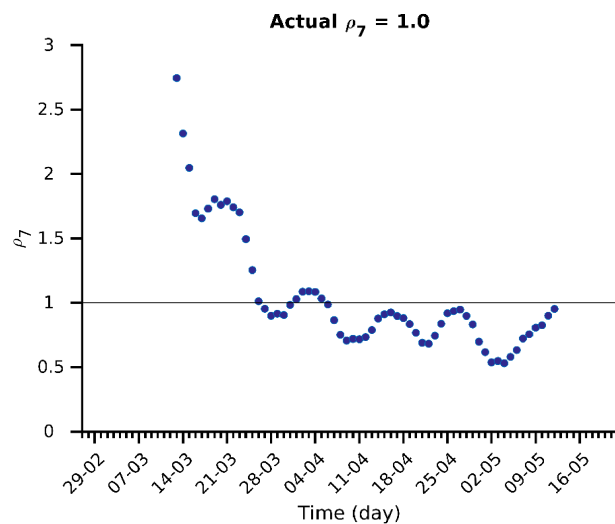
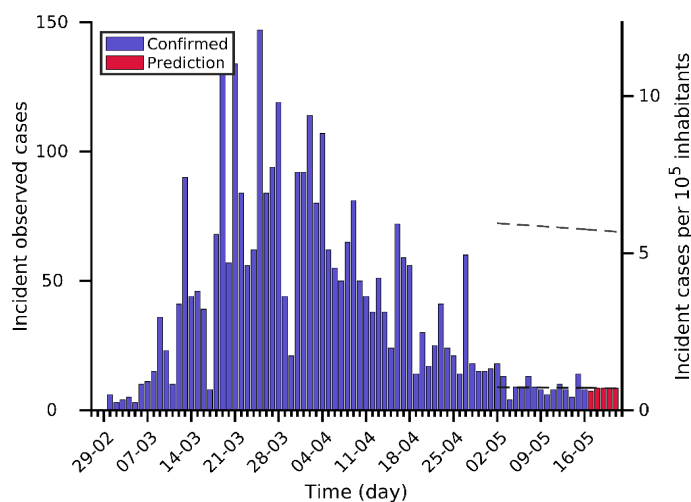
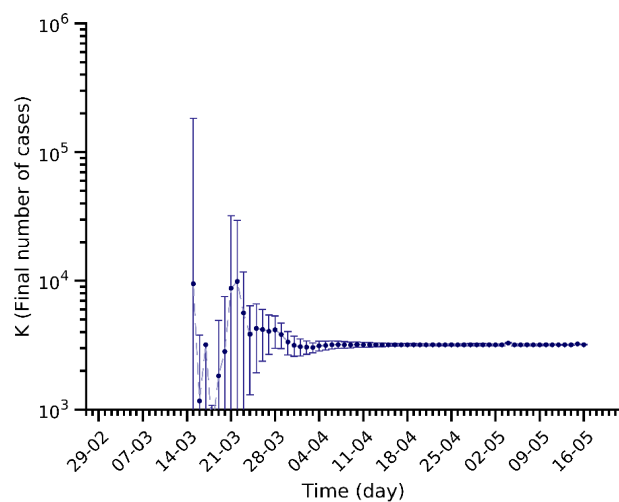
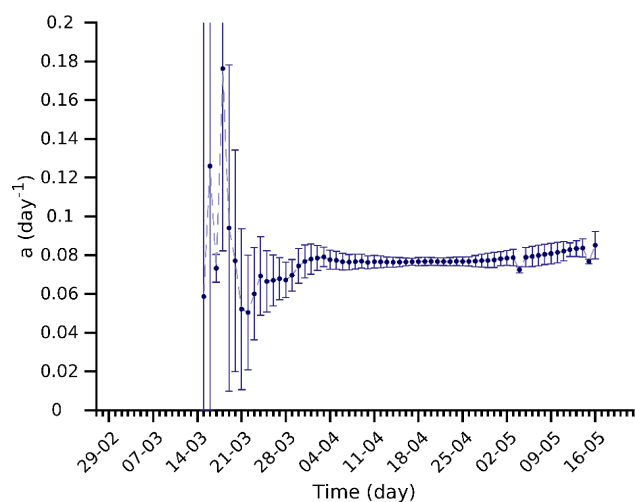
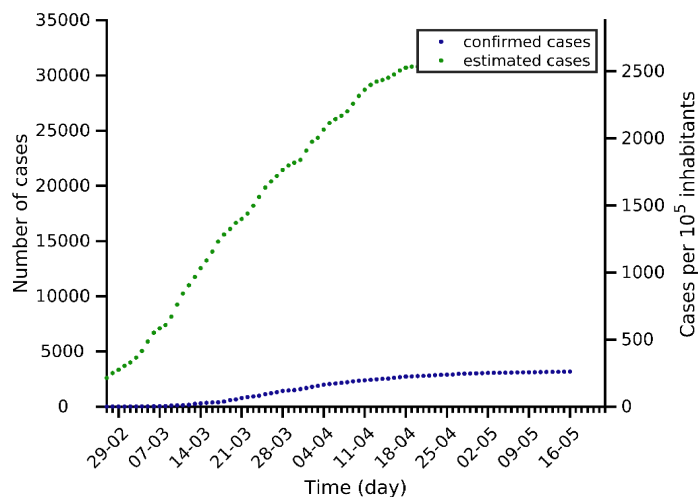
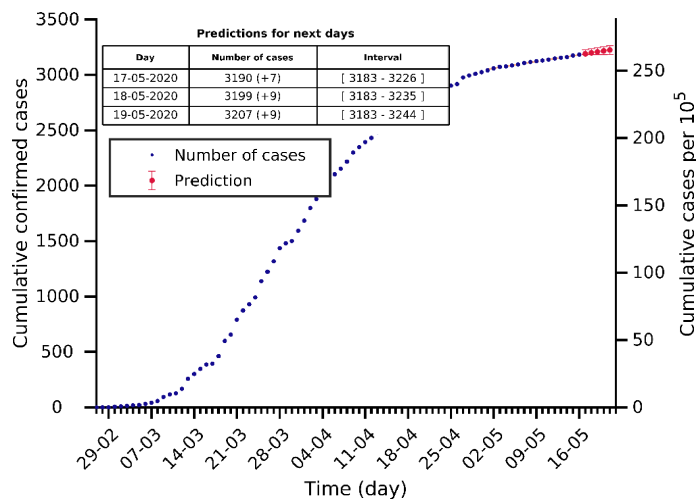
Trento 16-05-2020. Population: 0.5M. Current cumulated incidence: 804/10⁵



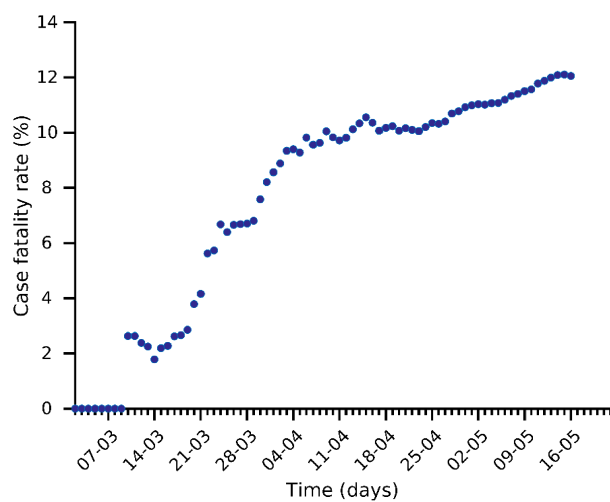
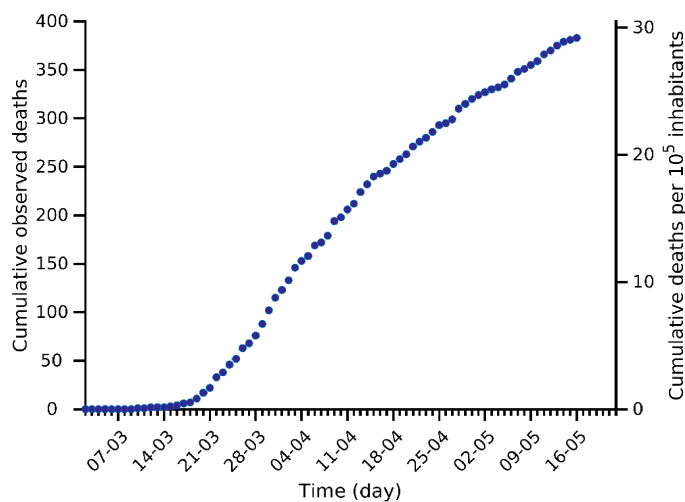
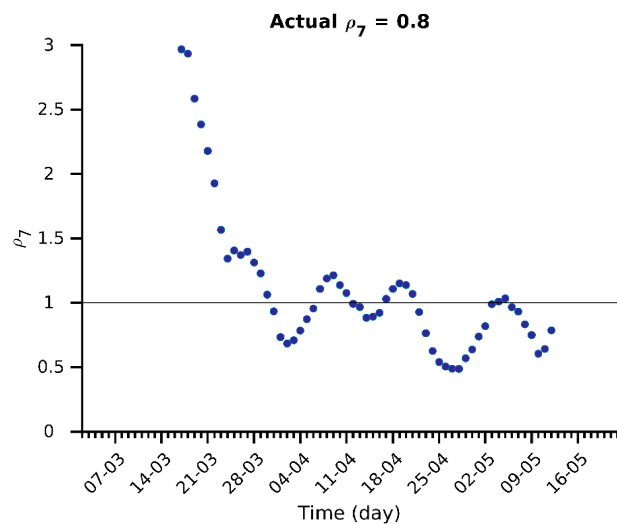
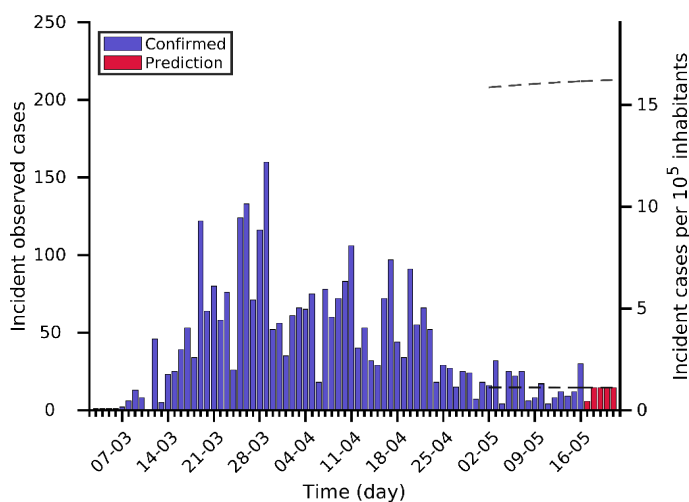
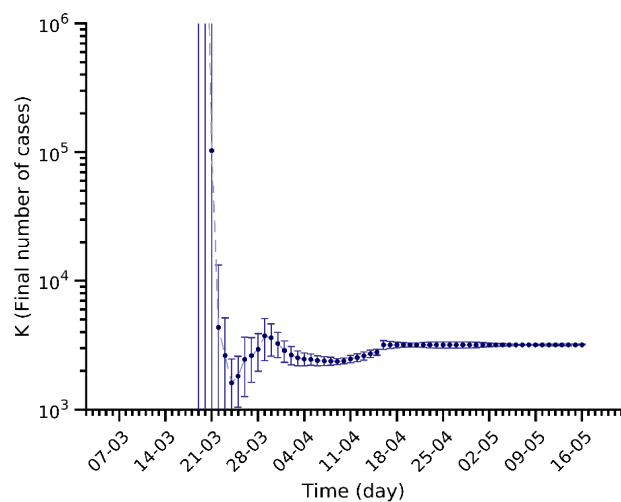
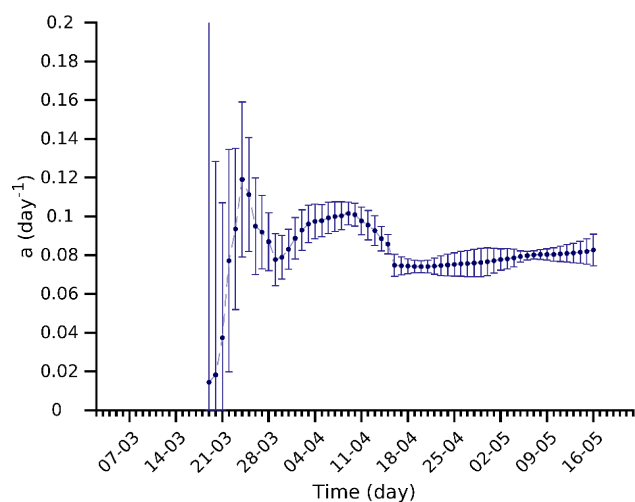
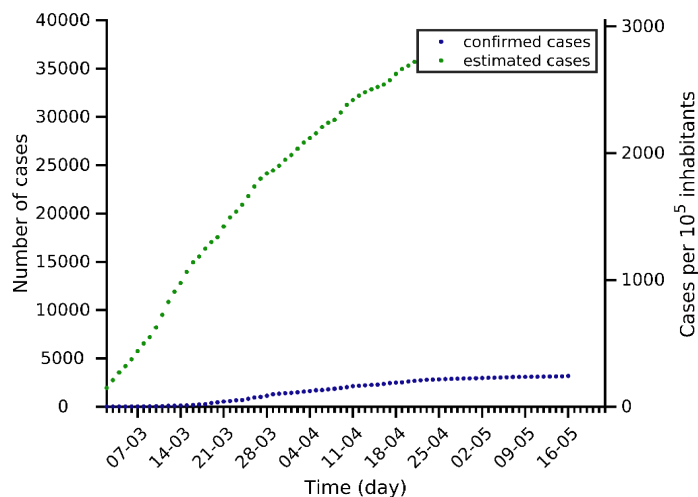
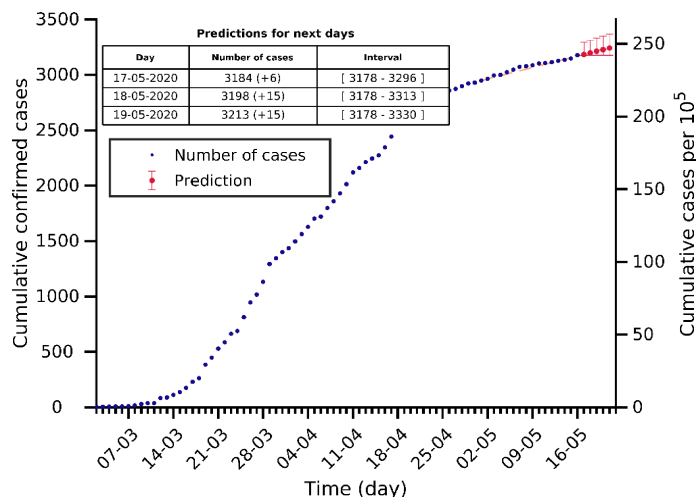
Sicilia 16-05-2020. Population: 5.0M. Current cumulated incidence: 68/10⁵



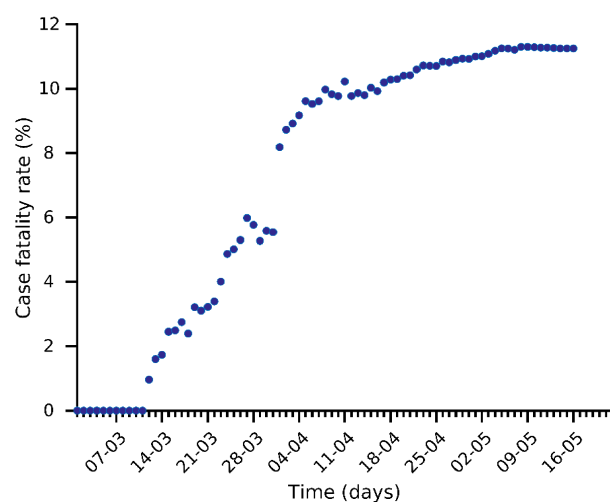
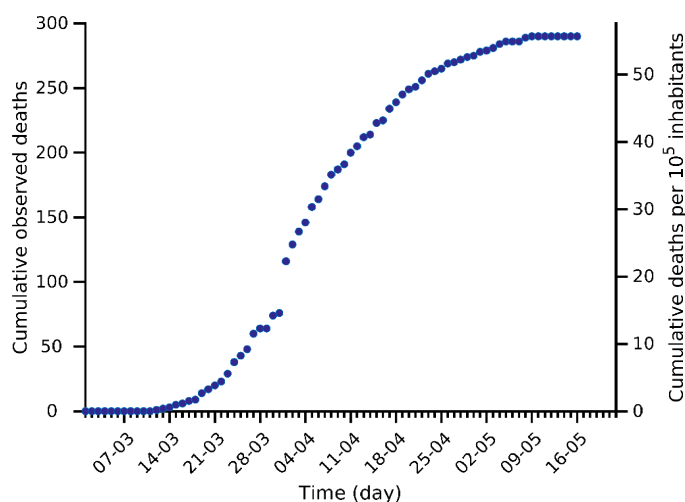
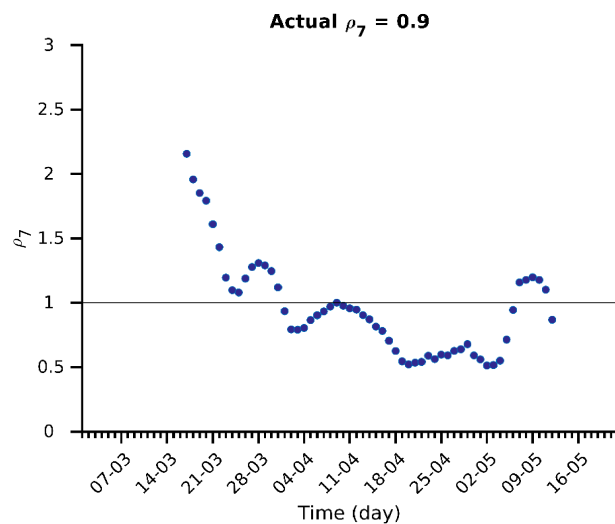
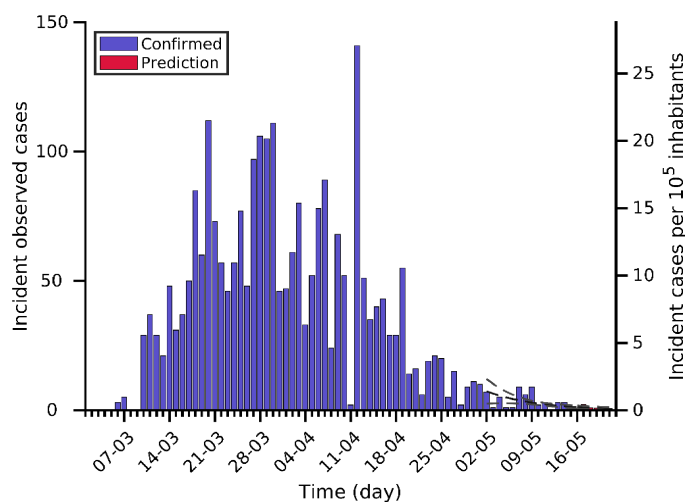
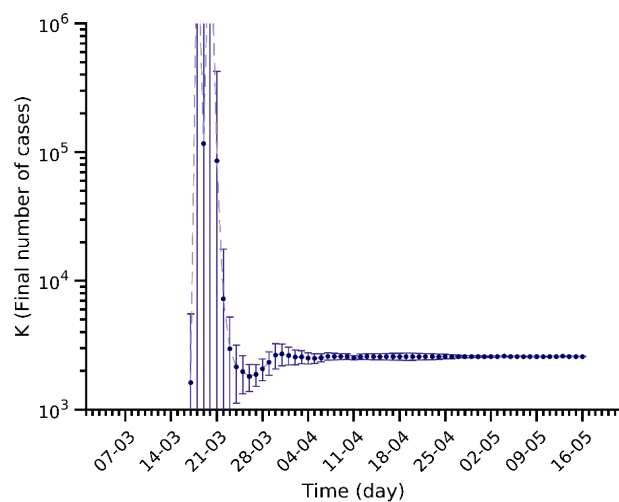
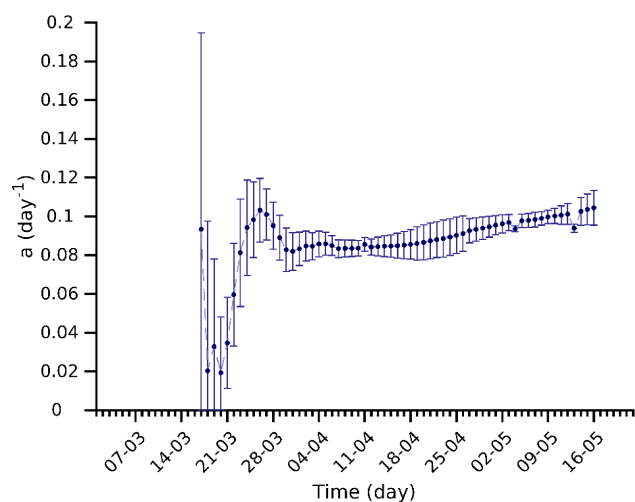
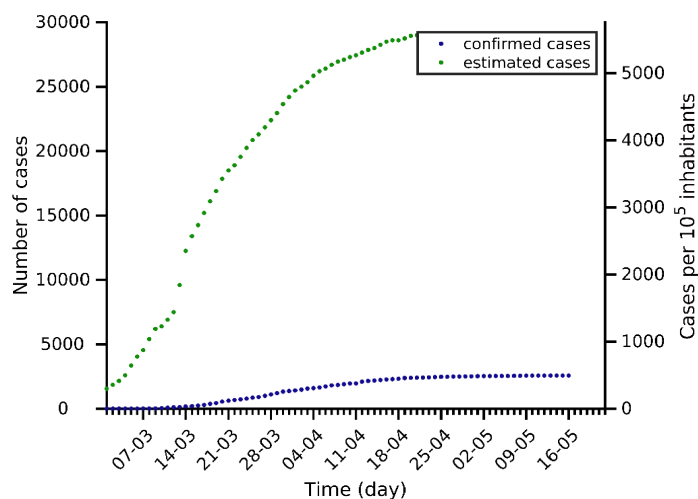
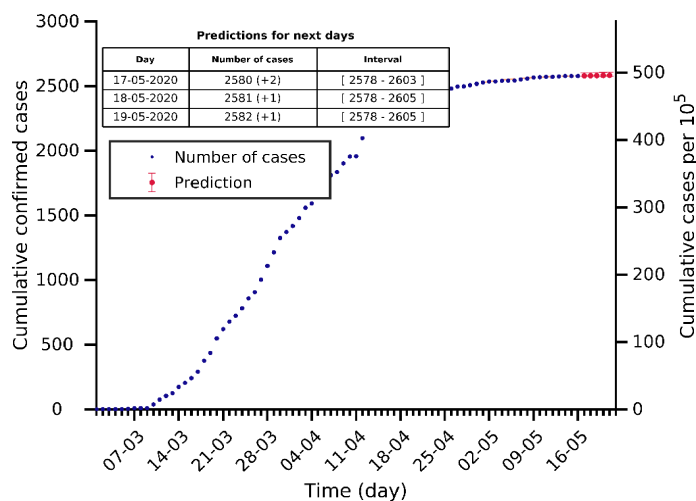
Friuli Venezia Giulia 16-05-2020. Population: 1.2M. Current cumulated incidence: 2



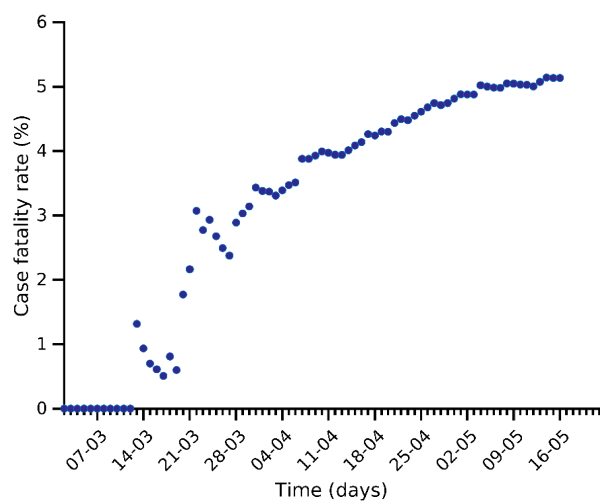
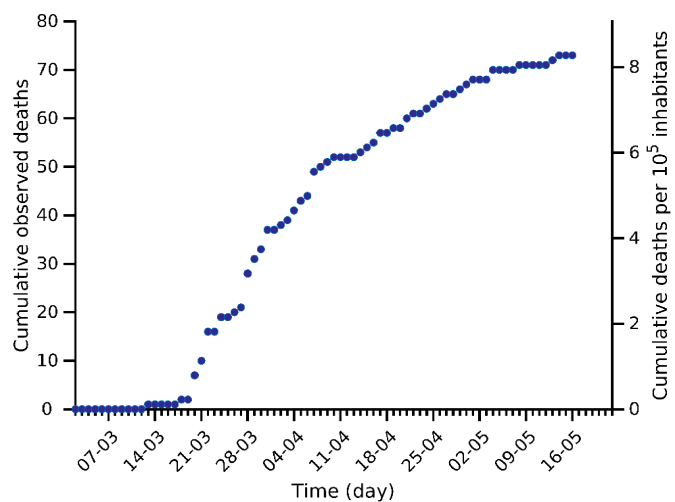
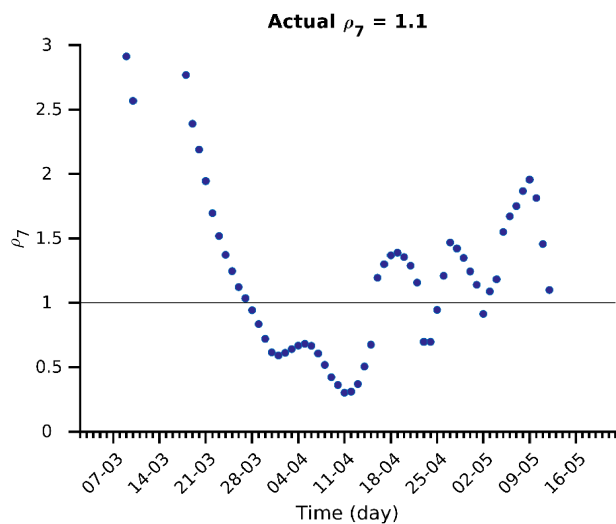
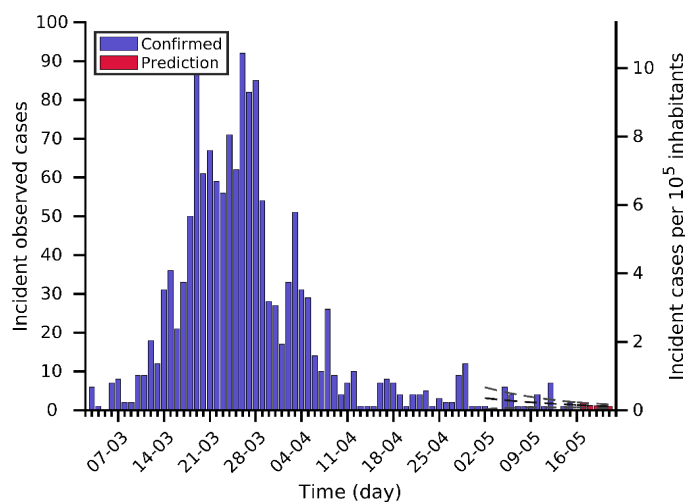
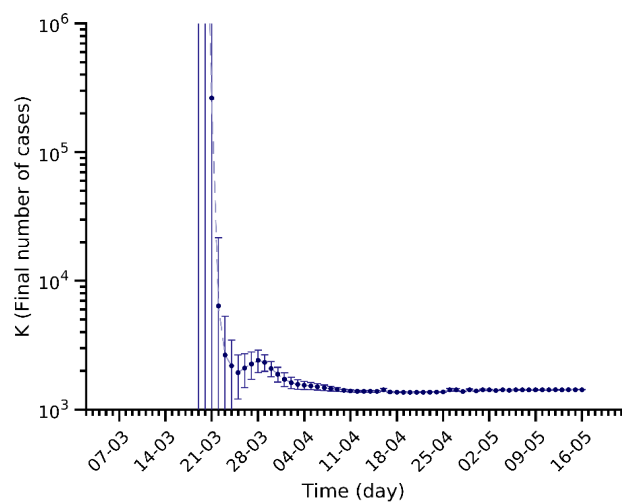
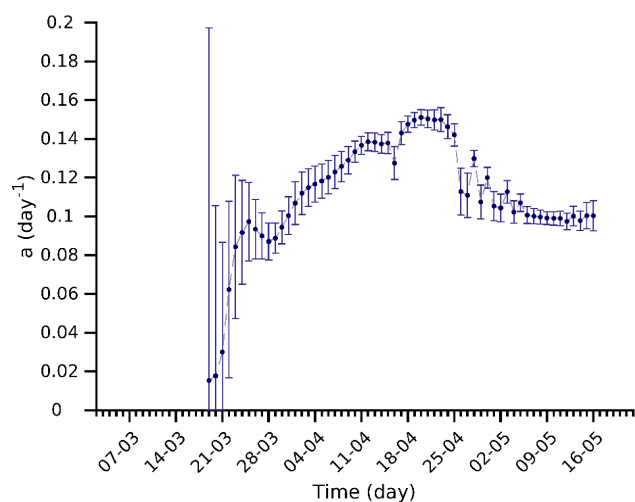
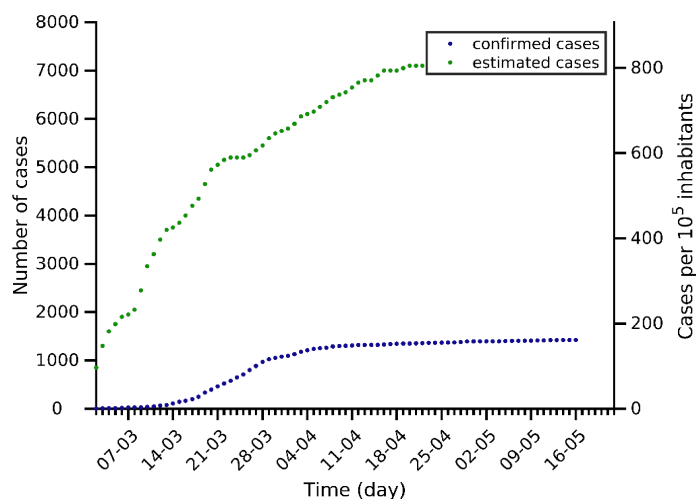
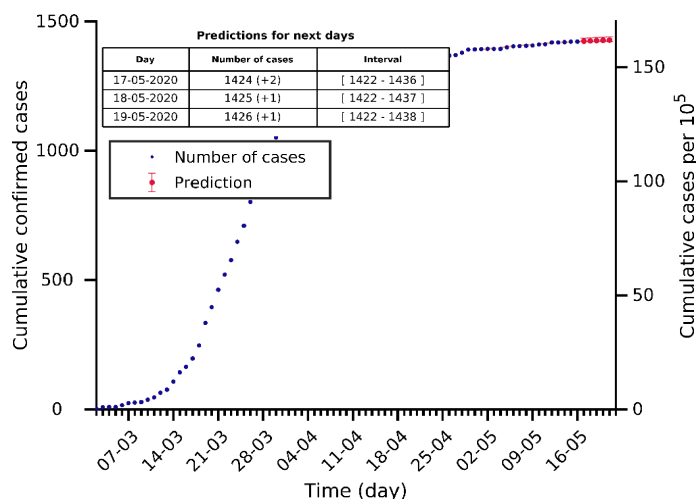
Abruzzo 16-05-2020. Population: 1.3M. Current cumulated incidence: 242/10⁵



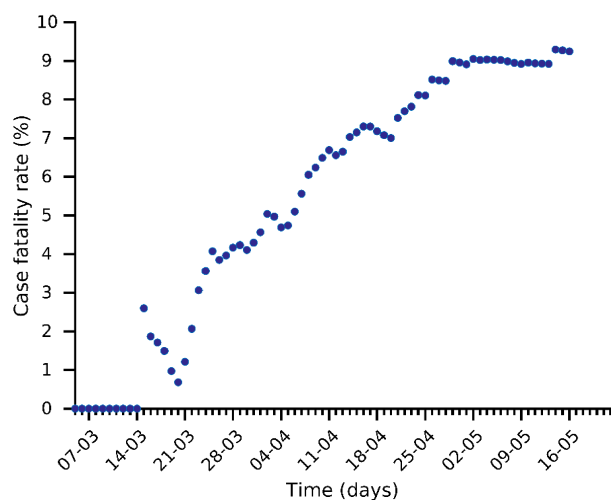
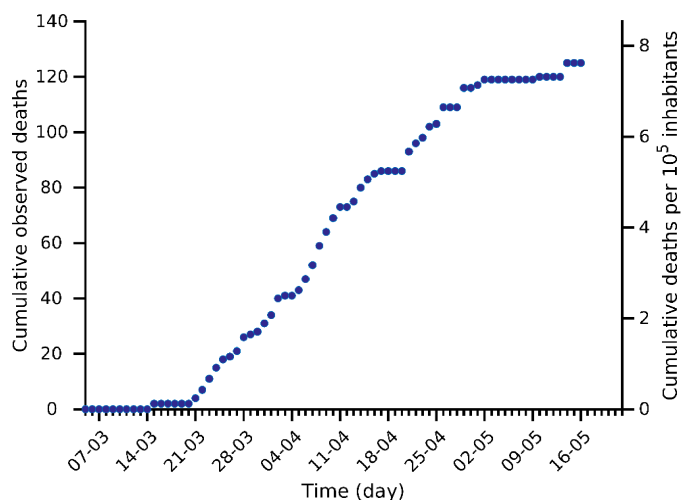
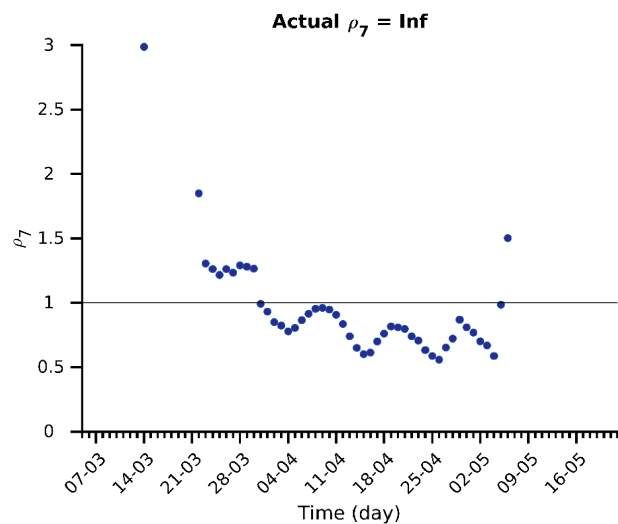
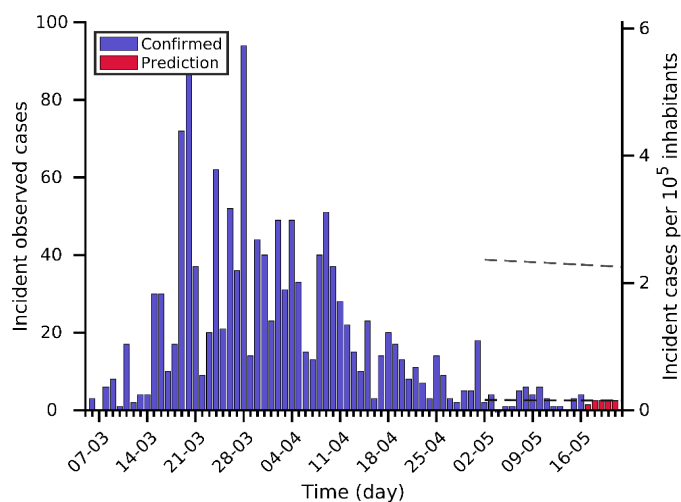
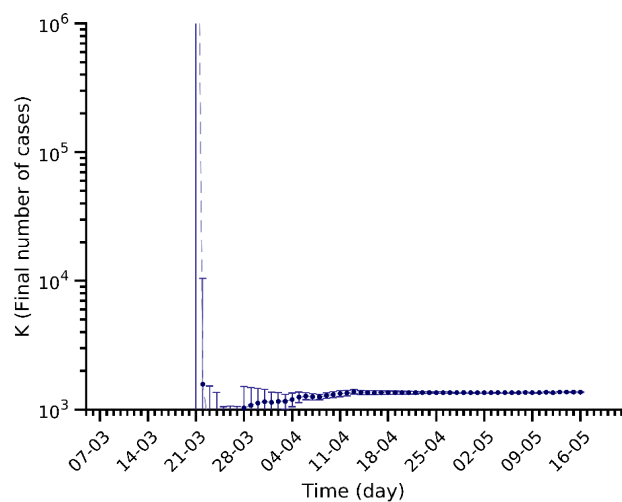
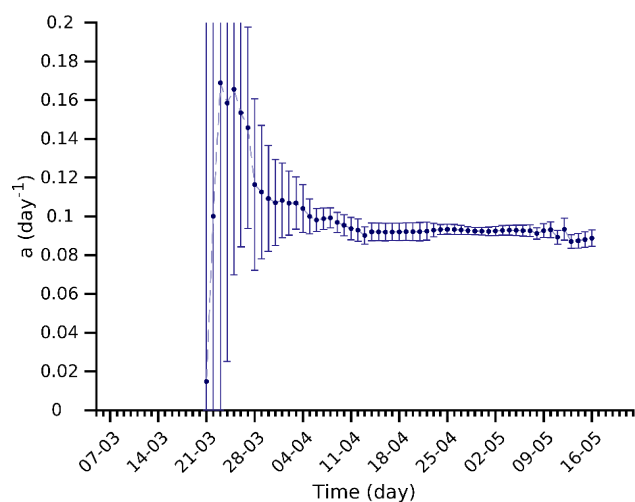
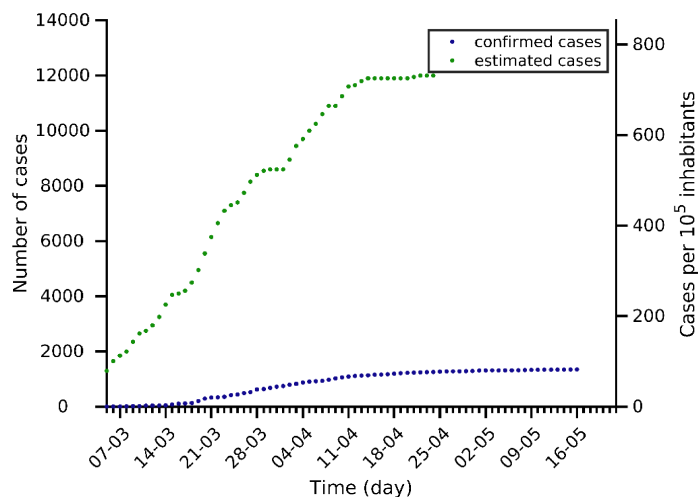
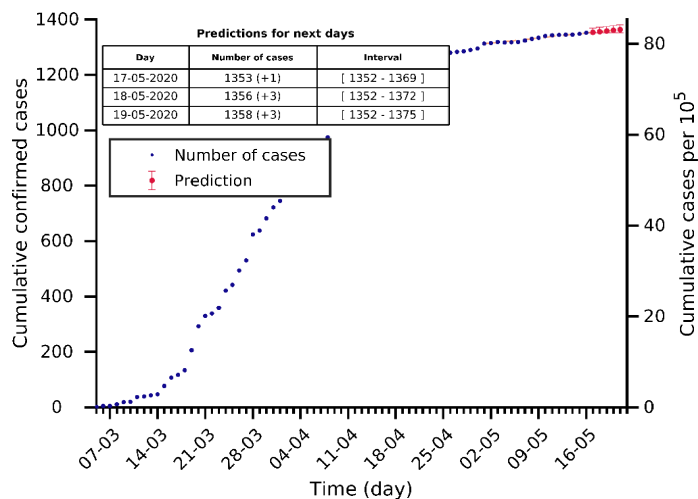
Bolzano 16-05-2020. Population: 0.5M. Current cumulated incidence: 495/10⁵



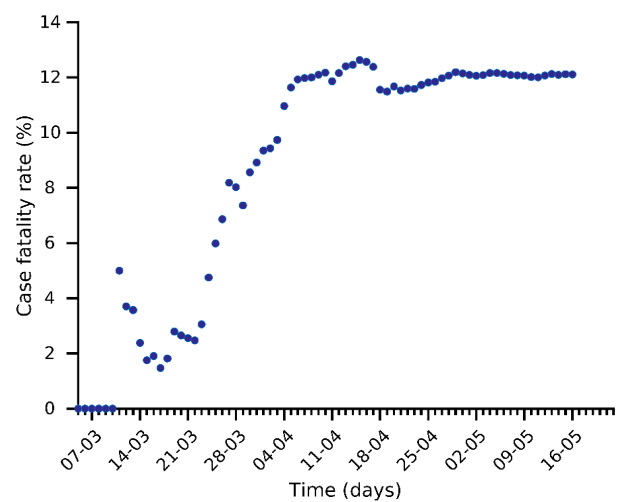
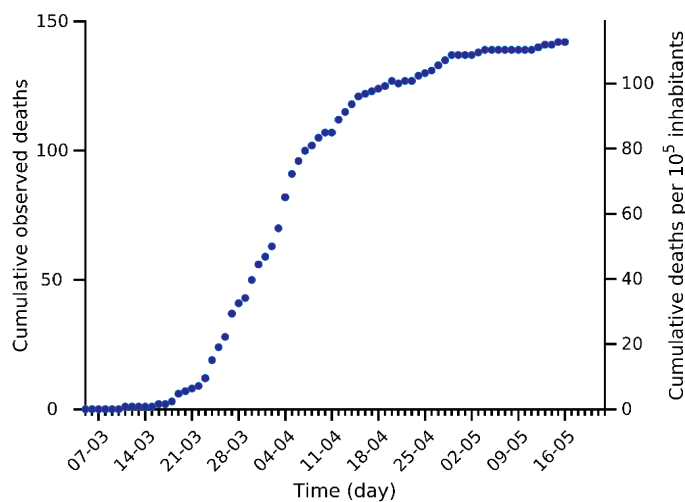
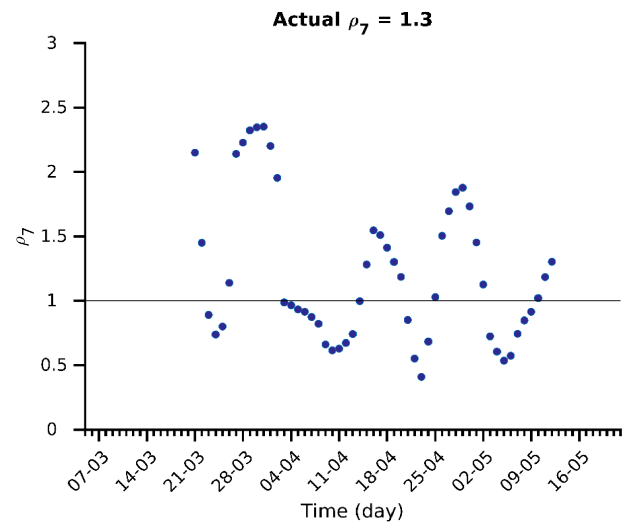
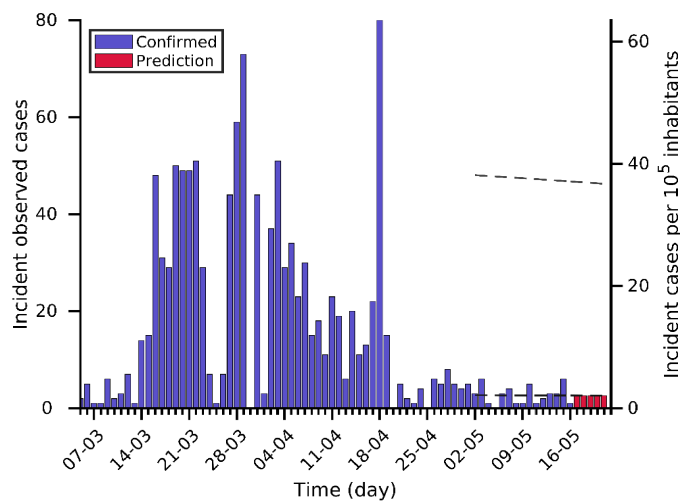
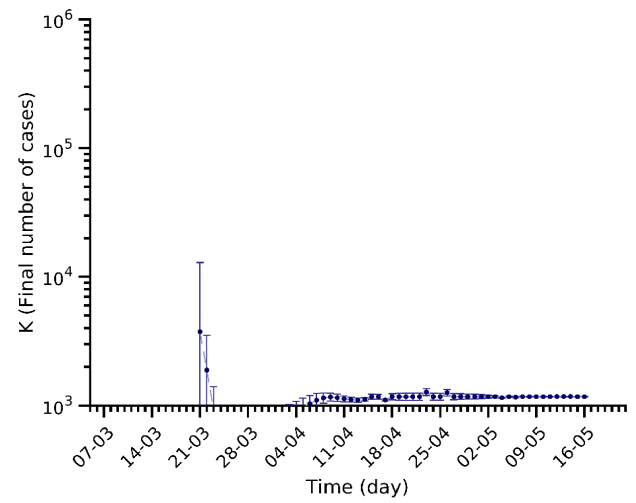
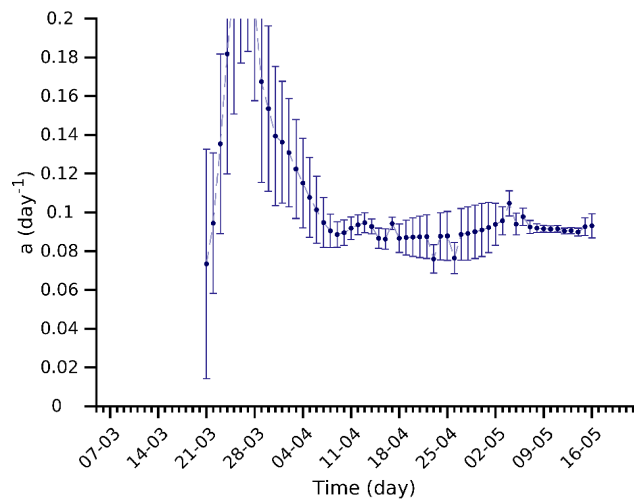
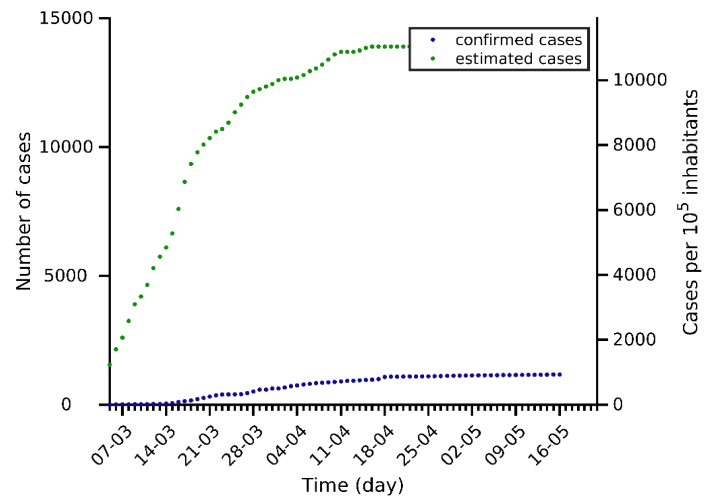
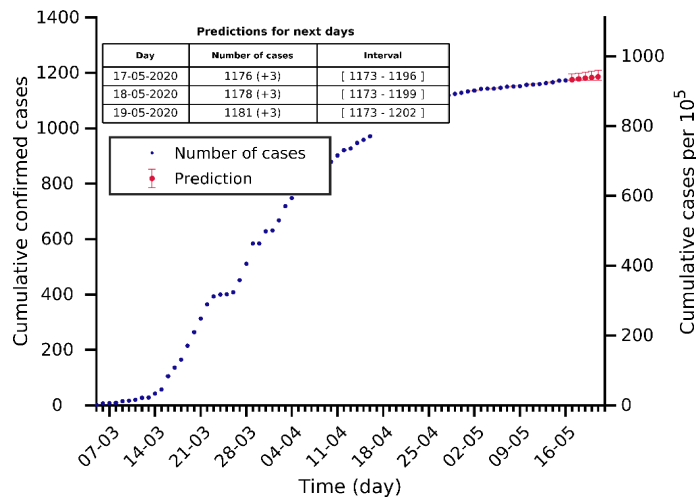
Umbria 16-05-2020. Population: 0.9M. Current cumulated incidence: 161/10⁵



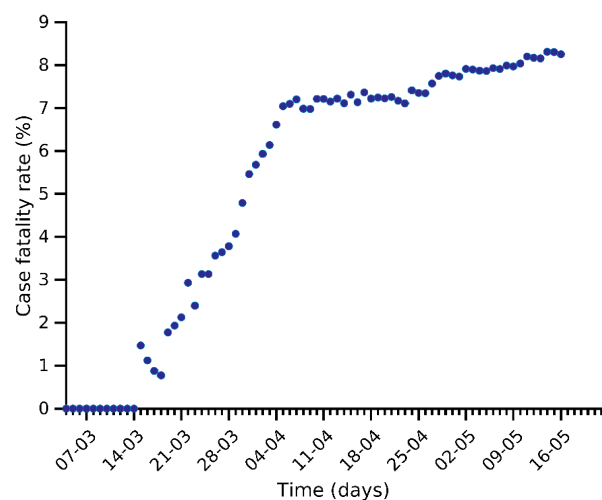
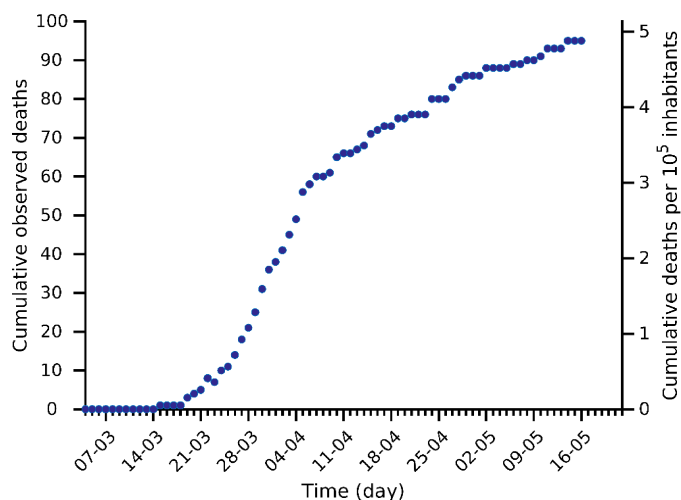
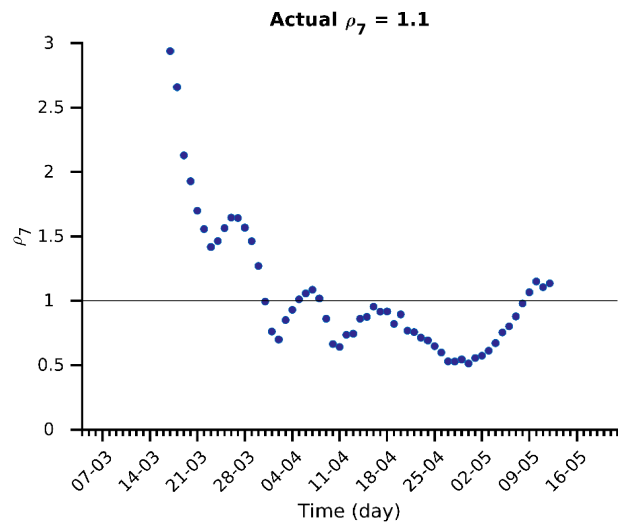
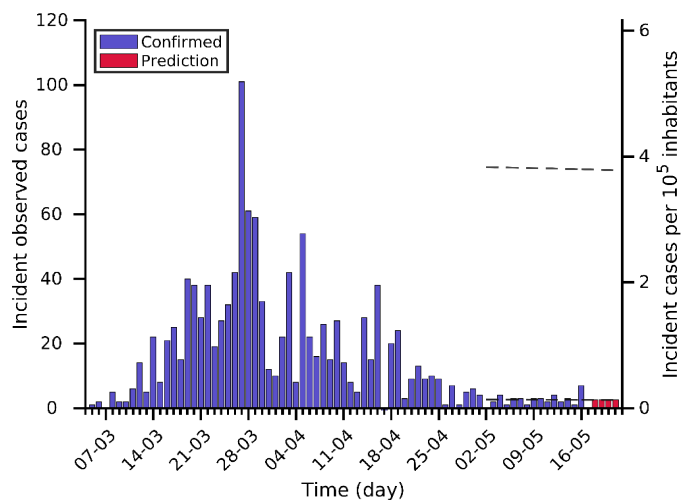
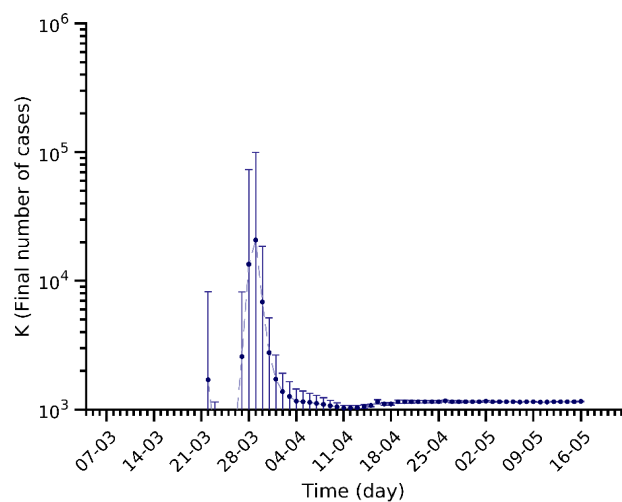
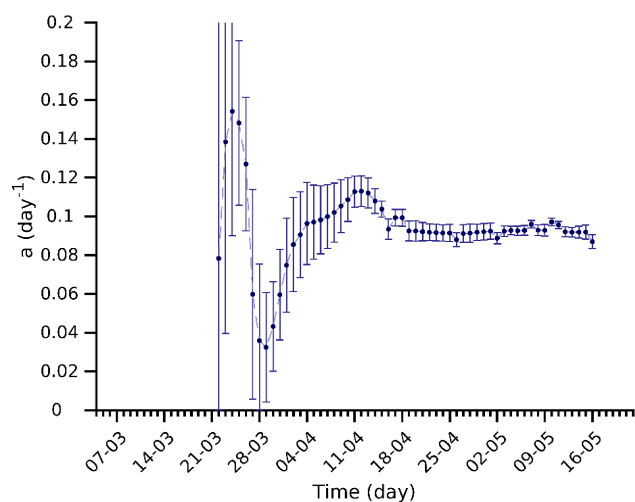
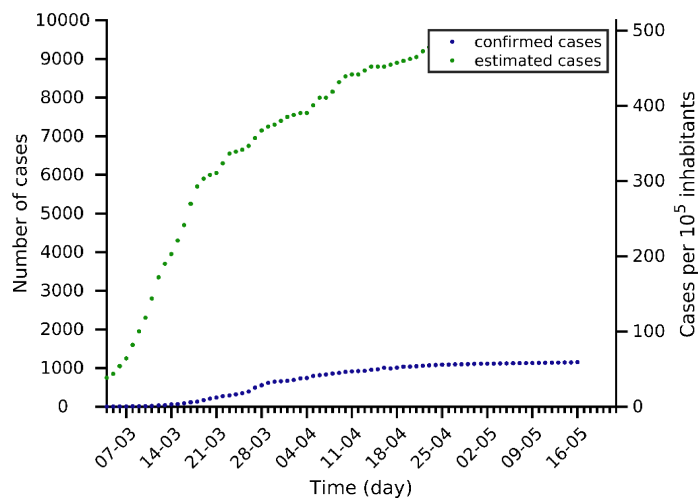
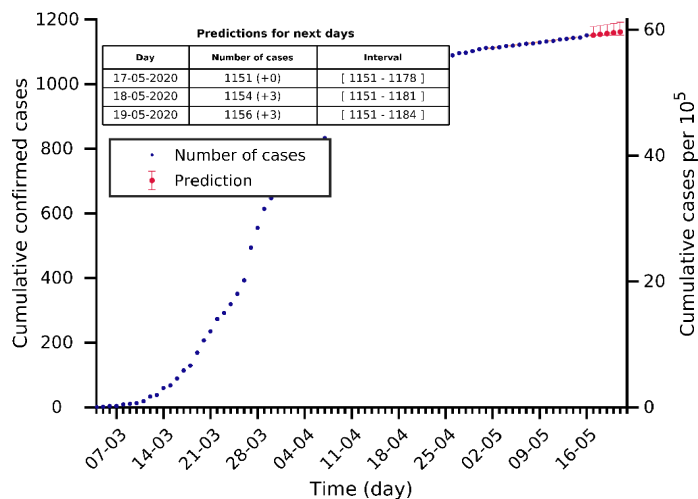
Sardegna 16-05-2020. Population: 1.6M. Current cumulated incidence: 82/10⁵



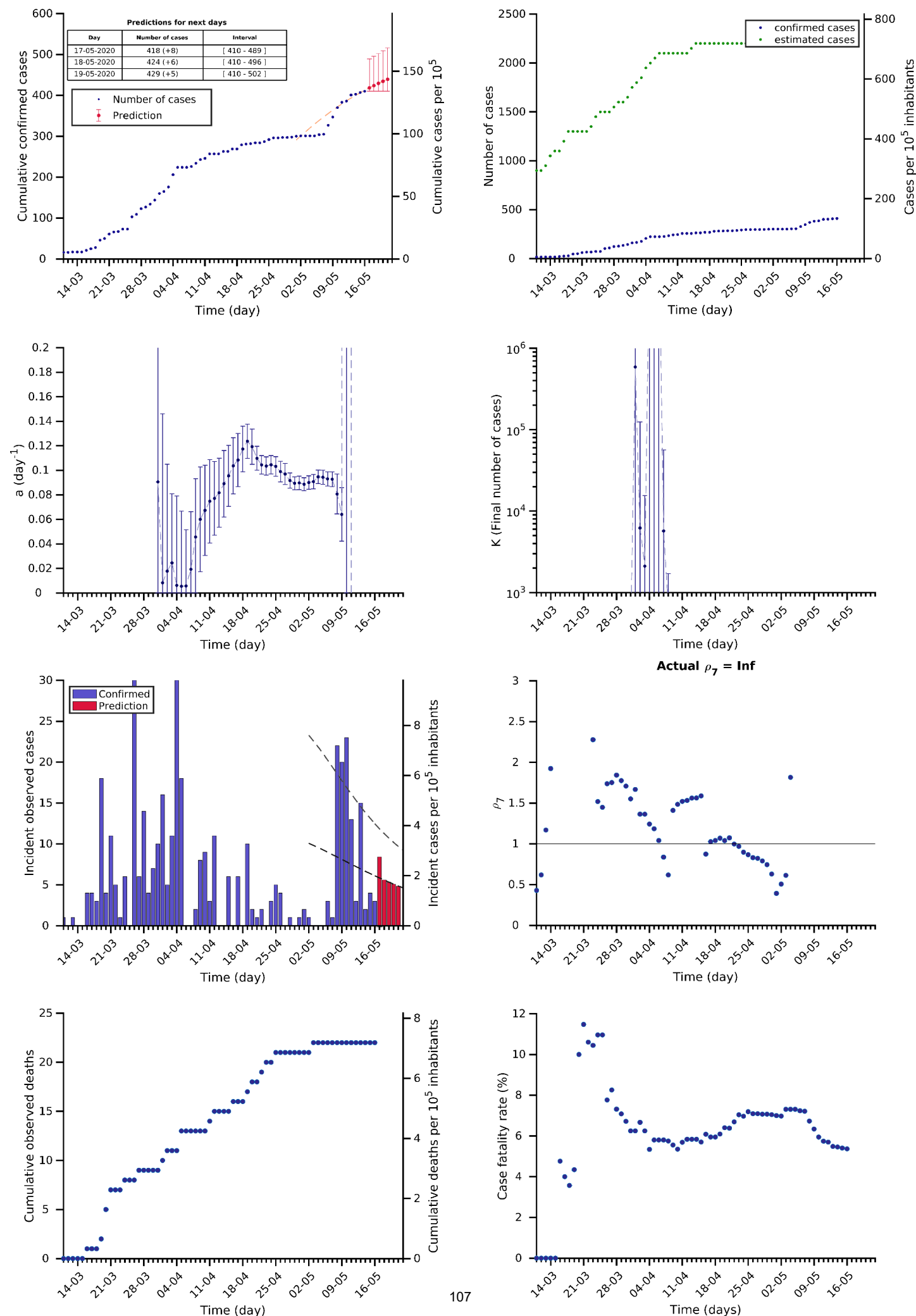
Valle d'Aosta 16-05-2020. Population: 0.1M. Current cumulated incidence: 931/10⁵



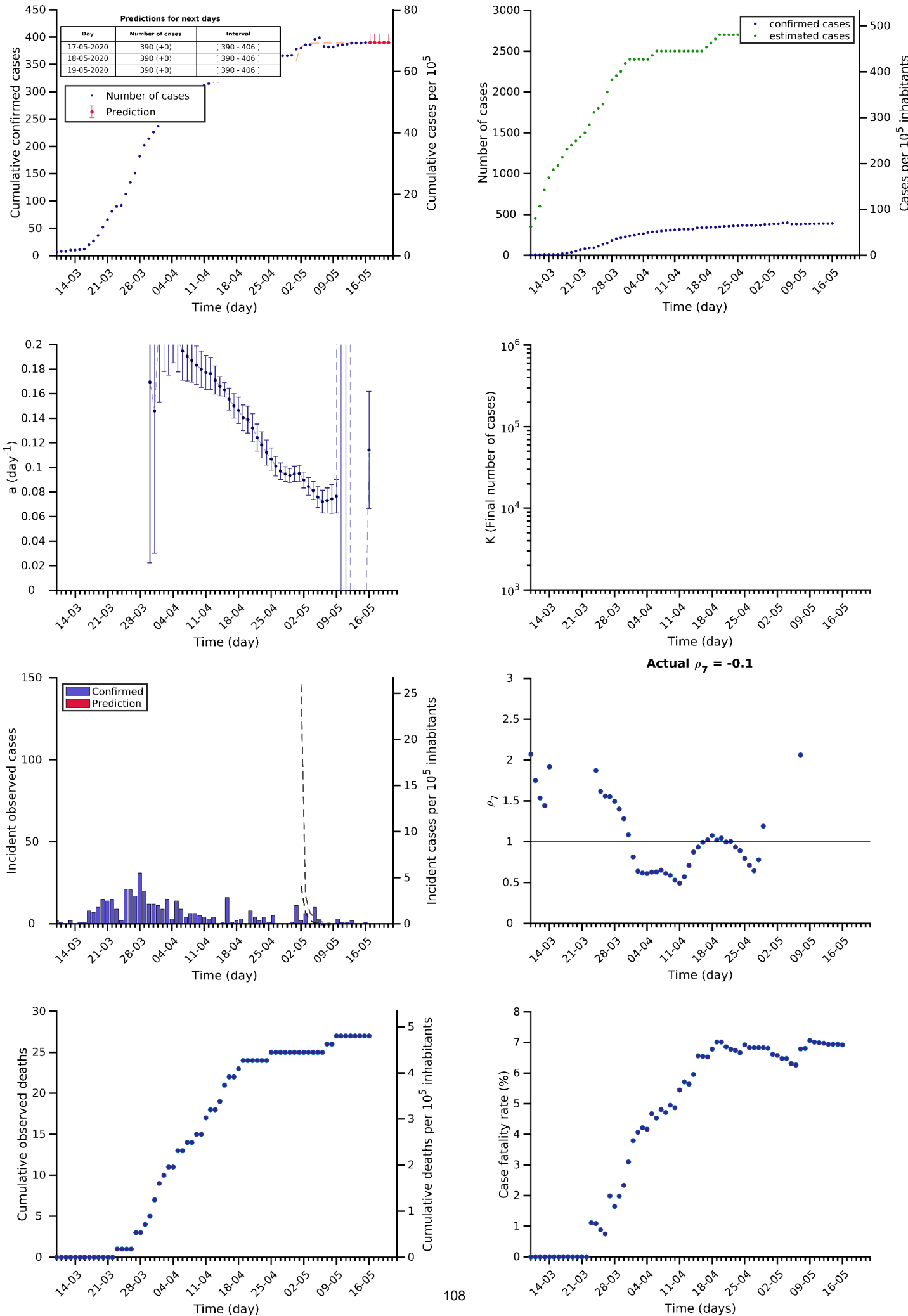
Calabria 16-05-2020. Population: 1.9M. Current cumulated incidence: 59/10⁵



Molise 16-05-2020. Population: 0.3M. Current cumulated incidence: 134/10⁵



Basilicata 16-05-2020. Population: 0.6M. Current cumulated incidence: 69/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports¹, from European Centre for Disease Prevention and Control (ECDC)² and from Ministerio de Sanidad³. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

¹ <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

² <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

³ <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁴ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁴ Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁵;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁶ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁵ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁶ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3